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Observations of the Annular Eclipse of April 7, 1940

By N. WYMAN STORER

A trip of 825 miles to observe a solar eclipse would probably seem like an afternoon excursion to a veteran eclipse observer, but it was more of an undertaking to one who had to travel only about 200 miles to see the eclipse of August 31, 1932, and hardly more than 25 yards from his own bed-room in the Van Vleck Observatory to the 20-inch telescope where he helped Professor Frederick Slocum observe the eclipse of January 24, 1925.

I was accompanied from the University of Kansas by Mr. William M. Bush, graduate student in physics, and Mr. Henry G. Horak, a senior majoring in astronomy. We left Lawrence at noon on Thursday, April 4, stopping that night in Stillwater, Oklahoma, at the home of Professor Harrison S. Mendenhall of the Oklahoma A. and M. College, who made the rest of the trip with us. We reached Conroe, Texas, at noon on Saturday, after driving the last 250 miles through pouring rain which continued through the afternoon. That had us pretty well discouraged, especially in view of the unfavorable predictions, but Sunday morning dawned spotlessly clear and remained so until well after the annular phase of the eclipse was over.

Conroe had been selected because it seemed to be the nearest town to Lawrence which was exactly on the center line of the eclipse. I had previously written to the principal of the Conroe Senior High School, Mr. John W. Gilpin, and he had offered us the use of the school premises. Both he and Mr. Hulon N. Anderson, Superintendent of Schools, were untiring in their efforts to help us. We were given access to all the facilities of the fine modern school building at all times, even early Sunday morning, and the cement tennis court, surrounded by a high wire fence, provided an ideal location for our telescope. To both of these men we are deeply grateful.

The 6-inch refractor of the University of Kansas was sent down by express, but the temporary mounting, made of lumber and held together entirely by bolts and screws, was packed very conveniently into my car. (One board which was too long to get in the car was made part of the box in which the tube was crated.) A photograph of this mounting, taken immediately after the eclipse, is shown in Figure 1, in which the north side has been turned toward the west for better light in the late afternoon sun.

The telescope tube, seven feet long, was secured to a plank the upper end of which was fixed to a polar axis in such a manner that it could be directed only to a declination of $+7°$, the position of the sun on April 7. Slight adjustments in the declination were provided at the lower end of the plank by a bolt, one end of which ran along the two boards making the curved line which shows in the picture. The telescope was kept in balance by a pail, the weight of which was increased as needed by adding water. Since the photographic exposures to be made were very short, no mechanical driving was attempted. This mounting worked perfectly after it was properly lined up, and the material used in making it cost less than three dollars.

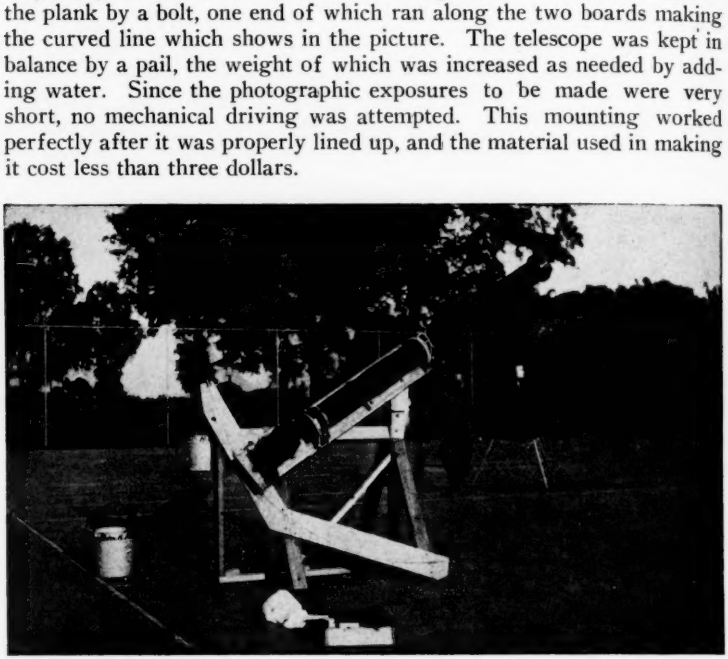


FIGURE 1
SIX-INCH REFRACTOR OF THE UNIVERSITY OF KANSAS ON ITS TEMPORARY MOUNTING FOR PHOTOGRAPHING THE ECLIPSE.

The exposures were made with a Graflex Camera box, kindly loaned by Mr. Oren Bingham of the university Photographic Bureau. The lens of the camera was removed so that the image produced by the 6-inch visual objective fell directly on the photographic plate or ground-glass screen. With a focal length of 95 inches the image of the sun was about $\frac{7}{8}$ inch in diameter. The ability to watch this magnified image on the screen was specially valuable in timing the second and third contact exposures to catch the "Baily's Beads." A Wratten "G" ("Minus Blue") Filter was placed in the position normally occupied by the Graflex lens, about five inches from the focus, and "Contrast" grade lantern slide plates were used, in a pack which made it possible to load twelve at one time. These plates were selected partly because of the anti-halation backing and partly for their fine grain. In spite of their general slow

speed and virtual insensitivity in the yellow region, exposures registered by the Graflex as 1/65 second were used. Probably a somewhat shorter exposure would have been better, as there were two spots on the sun which are very difficult to bring out in a print because of the density of the negative.

Exposures were made at ten minute intervals during the partial phase, and six were made during the annular phase, all being timed to the nearest second by my watch. Mr. Horak was given the task of counting the 376 seconds between second and third contacts, and exposures were planned for the counts 94, 188, 235, and 282. I judged the contact exposures without reference to the counting, but they were later found to be separated by exactly the computed 376 seconds. Of the 25 exposures made during the entire eclipse only one was not successful, and luckily for the symmetrical distribution of the photographs, that one was the exposure at the count 235. (Shhhh! I forgot to pull the slide!)

I had instructed Mr. Horak to start the count when the beads coalesced and he evidently judged that instant quite closely, for he and Mr. Bush using stop watches agreed within 0.8 second. Unfortunately, however, the beads were very persistent (reminiscent of the seemingly interminable beads at second contact in 1932) and therefore my central exposure, (Figure C, Plate IV), as timed by his count, was 7 seconds after the midway point between my contact exposures, Figures A and B, or, assuming the contacts were correctly timed, 6½ seconds after the closest approach of the shadow axis.

It is of interest to investigate how far away the axis was at the time of this central exposure. Sextant readings of the sun's altitude near noon on eclipse day gave a latitude which placed us 0.9 mile north of the center line as computed from the data of the *American Ephemeris* for our longitude. (The slight uncertainty in the longitude could make no appreciable change in this as the axis was moving only 6°.8 north of due east.) Thus, at the closest, the shadow axis passed slightly less than 0.9 mile south of us, and at the time of the central exposure we were about 2.8 miles perpendicularly from the axis, though due to its slant it touched the earth's surface at the time some 4.4 miles east of us.

It has been of further interest to make micrometric measurements of the width of the annulus on the original negative. An attempt was made to place the micrometer wire tangent to the smoothed limbs of both sun and moon, making allowance for mountains and atmospheric ripples. Below are given the means of measurements on two different days of the width at four points on the annulus. The average difference between the corresponding readings on the two days was 0.006 mm.

East	0.794 mm.	North	0.793 mm.
West	0.796 mm.	South	0.745 mm.

The close agreement between the measured widths at the east and west points is rather surprising, for with the late exposure the width on the

east side should have been about 0.055 mm. less than that on the west side. A known depression on the moon's east limb* would have made the annulus thicker at the east point by about 0.030 mm. but could not be solely responsible for the difference of 0.055 mm. Hence it seems evident that there must be some distortion of the image. This is borne out by the fact that the diameters of both sun and moon are greater in the north-south direction,—the sun's by 0.05 mm. and the moon's by 0.10 mm. The motion of the image during the brief exposure was first considered, and would have contributed to this result, but it amounted to only 0.003 mm. Suspicion next rested on some prismatic effect in the filter which was of Grade B, high quality plate glass but not optical. However, this seemed to be ruled out when another of the annular phase negatives was measured, and it was found that though the moon's diameter was again greater in the north-south direction, this time by 0.020 mm., the sun's was less by 0.035 mm. Apparently irregular atmospheric refraction must be held responsible for the equal width at the east and west points, and also for the difference at the north and south points, for those widths should have been almost identical at that time. However, the refraction was of the sort sometimes seen through a telescope, causing a star image to shift around without being blurred, for though the sun's limb is noticeably rippled in many places, it is still quite sharp even when viewed through the microscope. The atmosphere is responsible, but it will certainly be forgiven, for it almost exactly counteracted the damage caused by making the exposure 6½ seconds late.

Figure A (Plate IV) suggests that the true time of second contact may have been very slightly earlier, but the appearance of the beads in the enlargement of the third contact exposure, Figure D, seems to indicate accurate timing of the tangency. A sunspot shows faintly in the lower right hand (southwest) quadrant of the original prints of Figures B and C, but it may not appear in the halftone reproductions. The same may be true of the tiny but unmistakable roughness at the moon's limb due to mountains, especially in the southeast quadrant.

It was originally hoped to get an accurate check on the times of contacts, but unfortunately we were unable to pick up any radio time signals and had to rely on the rate of my watch which took a small jump during the trip. Using the extrapolated rates found immediately before and after the trip and giving double weight to the interpolated rate, the watch correction at eclipse time had a probable error of ± 2 seconds. This made our longitude uncertain by about the same amount, for sextant readings of the sun's altitude during the morning gave the local time with a probable error of only $\pm 0^s.2$. Our best available position was accordingly:

Latitude $+30° 17' 34'' \pm 4''$ Longitude $6^h 21^m 53^s \pm 2^s$

*Stearns, *Publ. A.A.S.*, **7**, 167, (1933).

The times of the contacts were found to be (C.S.T.):

Contact	Predicted	Observed	O - P
	h m s	h m s	s
1	2 13 04.1	2 13 29	+25.
2	3 49 46.2	3 49 45	— 1.2
3	3 56 02.6	3 56 01	— 1.6
4	5 17 23.4	5 17 04	—19.

The large errors in the first and fourth contact times were undoubtedly due to the small scale of the image being observed.

It might be added that an error of 1 second in the watch correction would cause a discrepancy of 1.4 seconds between the predicted and observed times of the eclipse, since it affects the two in opposite directions. (The shadow was moving east 1ˢ of longitude in 0ˢ.4 of time.) Thus, the mean "O — P" for the second and third contacts would be completely removed (assuming that the eclipse was exactly on schedule) if the watch was one second slower than assumed.

One further result of the trip which is worth recording was a series of photometric observations made by Mr. Bush with a Weston Universal Exposure-meter No. 650. A page of a note book was held normal to the sun's rays, and experiment showed that if the meter was held about ten inches above that and just out of the direct line of the rays, the reading did not change appreciably with small changes in the position of the meter in any direction. In all he made eleven readings distributed over three hours at times when he was not helping me with the telescope. His minimum reading at central eclipse indicated an intensity of light on the page about 10% of what it was when the eclipse began, and about 11% of the interpolated value of what it would have been without the eclipse.

Professor Mendenhall attempted to make a motion picture record of the eclipse on Kodachrome film. Unfortunately he was unable to get the camera he used soon enough to make any experimental exposures, and the result was that though he used a small stop, a filter, and a pair of Polaroid plates, still the film was over-exposed. However, he did obtain a record of the rest of us repeating part of our "routine" after the eclipse.

The trip was a thoroughly enjoyable experience to all of us, and while some plans did not work out, we did obtain a clear silhouette of the entire moon photographed when it was just 2.3 seconds of arc from the precise New Phase.

University of Kansas, Lawrence, Kansas, May 28, 1940.

The New McGregor Building and 70-foot Tower Telescope of the McMath-Hulbert Observatory

By HEBER D. CURTIS

The new McGregor Building and attached 70-foot tower telescope of the McMath-Hulbert Observatory of the University of Michigan was dedicated on May 25. Judge Henry S. Hulbert, President of McGregor Fund Trustees, formally presented this powerful new tool for solar research to the University of Michigan, and the gift was accepted by President Alexander G. Ruthven for the University. Short addresses were also made by Dr. Robert R. McMath, Director of the McMath-Hulbert Observatory; by Dr. Heber D. Curtis, Director of the Observatories of the University of Michigan; and by Dr. Charles F. Kettering, Vice-President in Charge of Research, General Motors Corporation. Dr. Kettering, in discussing the importance of work in solar research, alluded to our sun as a star upon which depends every manifestation of life and energy on this our earth, but stated that, in the final analysis, the sun does just two things,—"It pumps water, and it grows vegetables!" Another of his characteristically happy and concise extemporaneous definitions, which will strike a responsive chord in every research laboratory, was,—"To do the best research you must not have all the money you would like to have; you must instead have a little less money than is really needed for the research."

The McGregor Building is so named in memory of the late Tracy W. McGregor, of Detroit, founder of McGregor Fund, whose interest in this and other fields of astronomical research had always been keen. McGregor Fund not only gave $100,000 to cover the cost of the building, tower telescope, and apparatus, but has also made a grant for a part of the support of the work in solar research for the coming five-year period.

The new building is located to the north of the other buildings of the McMath-Hulbert Observatory, and is shown at the right in Figure 1, a view taken from the southeast. The building in the center is the 50-foot tower telescope, with which Dr. McMath and his associates have secured their remarkable motion picture studies of the prominences and other solar phenomena (over 400,000 individual pictures, or "frames," have been taken with this tower to date!). The lowest dome to the left represents the original observatory, and at first housed the 10½-inch pyrex reflector with attached motion picture mechanisms which was used for the earlier work of the observatory on lunar changes and the motions of planets and satellites; the spectroheliokinematograph was later added to this telescope and has been of great service in securing concurrent mo-

tion pictures in Hα while the 50-foot tower was making its records in the K line of calcium. The spectroheliokinematograph, working with a telescope of only 10½ inches aperture, may be regarded as the starting point of the solar work at the McMath-Hulbert Observatory, and gave the stimulus to the erection of the 50-foot tower telescope and the latest 70-foot tower. For the spectroheliokinematograph showed the existence of many short-lived solar phenomena whose existence had not previously been suspected. The first motion picture of a solar prominence with this instrument was secured in early August, 1932; these films, while now regarded as rather crude in comparison with later results, were shown before numerous societies or organizations and some of the re-

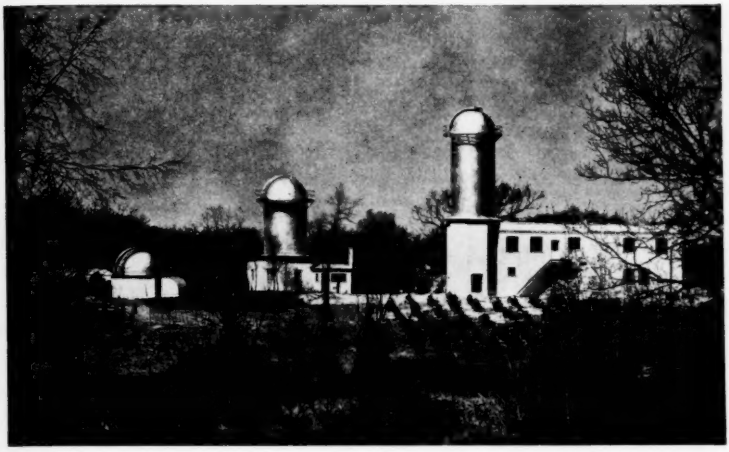


FIGURE 1
THE MCMATH-HULBERT OBSERVATORY FROM THE SOUTHEAST

sults were published in 1934. As a consequence, the 50-foot tower telescope was completed on July 1, 1936, and the first successful prominence film with the new tower was secured on the following day, July 2, 1936. The 10½-inch reflector is now being completely remounted with a 24-inch pyrex mirror, and will be a memorial to the late Francis C. McMath, one of the three original founders of the observatory.

The new McGregor Building is two stories in height, and covers an area of 5,600 square feet, with the 70-foot tower which is a part of the building at the south. On the first floor is a drafting room, a beautifully equipped modern machine and instrument shop, smaller film storage, cutting, and dark rooms, and a long laboratory room. On the second floor are the offices for the staff, a measuring room, a large dark room with unusually complete equipment for enlarging and other photographic work, a second long laboratory room, the library, and a projec-

tion booth which serves to project the films of solar phenomena for study, or for examination by visiting scientists.

The tower telescope and its foundations are throughout of unusually massive construction to obviate any risk from vibrations. The tower is double; the outer tower carries the dome, the floors and other structural elements, the ladders giving access to the various levels, as well as an electrically driven steel elevator, which rises in the space between the walls of the outer and inner towers and will serve to carry apparatus, etc., to the dome level nearly 70 feet above.

The inner tower, on the other hand, carries only the coelostat mechanism, now under construction, and the other optical parts of the tower telescope proper, through which the light from the sun collected by the mirrors of the coelostat will pass vertically downward. There is no well beneath the 70-foot tower, as is the case with the 50-foot tower. Instead, the light may be sent out laterally through openings in the walls of both towers and into instruments placed within either of the two long laboratory and observing rooms mentioned above.

The previous work of the McMath-Hulbert Observatory has been greatly impeded by lack of adequate working space, so that most of the work of design and measurement has had to be carried out in the basement of Dr. McMath's residence. The greater convenience and efficiency that will be secured through adequate working spaces for offices, measuring rooms, laboratories, and dark rooms is, of course, self-evident, and there is no piece of delicate mechanism, large or small, that can not be very quickly constructed in the unusually complete machine shop. But these advantages, while highly desirable, in no way represent the real purpose of the new McGregor Building. Thus a brief statement may be in place with regard to the work that is being planned for this new solar tower, and why this added method of attack is essential for the study of the sun.

Dr. McMath's remarkable films of solar phenomena in motion have aroused the interest and admiration of astronomers the world over, and have given us a vast amount of data for measurement of the velocities of matter in motion upon the surface of a star, which must form the working basis for all future theories of the sun. The motion pictures have given us the projections of these motions upon a plane (very nearly) that passes through the sun's center and is perpendicular to the radius vector of the earth. These measures thus give us the X and Y coördinates of the motions on the plane of projection. It has long been felt that these velocities in the X and Y coördinates only were insufficient to make a decision possible between theories of actual matter in motion, or certain theories of traveling luminescence suggested by some. To meet this need, velocities in a third, or Z, coördinate (radial velocities in the line of sight) have been secured during the past year, concurrently with the values of the X and Y coördinates, by the aid of auxiliary apparatus of unusual ingenuity.

A worker in other fields of the exact sciences might well feel that concurrent records of the phenomena of motion in three rectangular coördinates, plus records in different wave-lengths (as Hα and K), should be enough to satisfy any reasonable theorist. But a moment's reflection will bring home the fact that, for the sun at least, these velocities in three coördinate directions tell only part of the story, and perhaps far less than half. For a mere knowledge of velocities and directions of motion leaves many questions still unanswered, whose importance to our knowledge of the sun we can at present glimpse but faintly.

Some of these as yet unanswered questions are,—what are the actual temperatures of the streamer knots, or other phenomena such as explosions seen on the solar disk, that are traveling at speeds of 10 to 50 or more miles per second? Even more important, because of its possible connection with such familiar terrestrial phenomena as aurorae, magnetic storms, and radio reception, is an accurate knowledge of the electrical and magnetic conditions accompanying these solar storms. Are there, for example, increases in the output of ultra-violet light, whose pulses may well affect our radios? How much heat change, or how much change in electrical or magnetic forces is involved? This fourth parameter that we wish to know is thus not spatial like the other three. But we might term it an energy, or E, coördinate, and say that it has everything to do with the actual nature and the cause of these solar phenomena; it is an energy coördinate in that it will measure the energy relations on the sun itself and the possible terrestrial effects of these moving forms that so fascinate us when thrown on the screen.

The work of the new 70-foot tower telescope will thus be, by far, more of a physical than of a purely astronomical nature. The apparatus and attachments that are planned for use with the new tower telescope will be largely those of the physical laboratory,—bolometers, photometers, instruments for evaluating the electrical or magnetic characteristics of solar streamers, etc. By no means are all the paths of research with the new McGregor Building as yet clearly mapped; there may be many difficulties and pitfalls; much apparatus may have to be devised as the work progresses and the need for new instrumental adjuncts arises.

For the study of such energy relations through the most advanced techniques of modern physics and astronomy, it is our belief that the new McGregor equipment will form a tool of great power; an instrument and a new method of attack which will place the McMath-Hulbert Observatory in the front rank of the world's solar observatories. We do not know as yet just what will be found; if we did know, there would be no need for the new tower telescope and laboratory. But we feel sure that the results will be of great importance for a more nearly complete knowledge of our particular star, and that possible results of great scientific interest and value may eventually have important terrestrial relationships or application.

With the additions that have been made to make a better use of the

new equipment, the staff of the McMath-Hulbert Observatory is as follows:

Dr. Robert R. McMath, Director
Judge Henry S. Hulbert
Mr. Harold E. Sawyer, Assistant Astronomer
Dr. Orren Mohler, Assistant Astronomer
Mr. John T. Brodie, Assistant
Mr. George Malesky, Engineer and Observer
Mr. Charles Guenther, Instrument Maker
Miss Marjorie Strong, Secretary

Shadow Bands

By RICHARD L. FELDMAN

(PART IV)

Descriptions of the various aspects of the shadow-band phenomenon have been detailed in previous articles.[1] Any explanation of their cause should fit the observations closely. A diffraction theory can do this.

Since diffraction is not a subject to be pursued so lightly as pin-hole images and refraction by air-waves, the casual reader is referred to the text, "Fundamentals of Physical Optics," by Jenkins and White (McGraw-Hill). I shall employ their symbolism hoping thereby to avoid ambiguity. Reference is particularly made to the first five pages of Chapter V, the chapter heading of which is "Fraunhofer Diffraction by a Single Opening."

The eclipse situation falls into the class of Fraunhofer diffraction because both the "source" (the sun) and the "screen" (the earth) are, effectively, at infinite distances from the "aperture" (quoting Jenkins and White). The common laboratory experiences with Fraunhofer diffraction, as related in the textbooks, seem to be gained with the plane waves of light striking a slit. In the celestial case we can treat the plane waves as diffracted at the edge of an opaque object. The waves are not rendered plane in this case by the use of lenses, but owe their freedom from divergence to the extreme distance of their source. We are not dealing with Fresnel diffraction in which the waves diverge.

There is an aspect of the situation, however, which makes one think of diffraction by a slit. It is this,—that the slit width, the width of the aperture, may be varied, attended by characteristic changes in the diffraction pattern. In the sky, instead of a changing slit-width we have a changing source-width as the sun enters and emerges from totality. But, in effect, it is like a slit at the distance of the moon and having only one side to frame it.

[1] Part I, POPULAR ASTRONOMY, **46**, 187; Part II, *ibid.*, **48**, 2; Part III, *ibid.*, **48**, 182.

There is another feature which is absolutely unknown in the laboratory experiences with either type of diffraction. It is the movement of the source towards and away from the "slit" and the "screen" at great speeds, the difference between which may be as great as 4.2 kilometers per second. I refer to the motion of the eastern and western limbs of the sun which have been studied with the aid of the Doppler effect and the consequent shift in the spectral lines. Where a pole of the sun peeps over the bulk of the moon there will, of course, be a minimum of motion of the "source."

There is yet another point of difference from the laboratory set-up. Whereas the darkroom screen or photographic plate are meticulously mounted at right angles with the incident light, in the case of the shadow bands, viewed as a diffraction effect, the earth's surface as the receiving screen lies at all possible angles with respect to the incident light.

Fresnel diffraction is rejected because the fringes or diffraction bands produced thereby are found to be most widely separated adjacent to the opaque obstacle. The opposite has been observed. S. A. Mitchell, discussing the reports of the bands observed January 24, 1925, ("Eclipses of the Sun," third edition) says: "The general consensus of opinion of the very large number of observers taking part was that the shadow bands were narrowest, most distinct, and most sharply defined immediately before and after totality, and that they became broader, farther apart, and more indistinct until they disappeared, with increase of width of the solar crescent."

Illustrative of the reports on which Dr. Mitchell based his summary are the following:

(From my notes.—R.L.F.)

N. E. Wheeler, physics instructor, Colby College, observing at Westerly, Rhode Island.—Bands "became darker, narrower, closer towards totality; became fainter, further apart after totality."

Sebastian Albrecht, Dudley Observatory, observing 5 miles south of Poughkeepsie, New York.—Bands were 8 inches apart at first, narrowing to 5 inches apart. After totality the separation increased to 18 inches.

Wesley W. Canfield, East Canaan, Connecticut.—Stated that "separation increased with increase from totality."

E. H. J., reported by Wilford M. Wilson, meteorologist, Ithaca, New York.—At first bands were very faint, about 1 foot in width and separated by light spaces of about 20 inches. "As totality neared they became more strongly defined, smaller, and closer together, until just before totality they were estimated at one and one-half inches in width, separated by light spaces of two and one-half inches; after totality this process was apparently reversed, the bands growing dimmer and farther apart." They were seen for 10 minutes before and 10 minutes afterwards.

In addition, a number of the reports stated that the speed was greatest when closest to totality, observations which, as my interpretation will show, indicate the same thing as quoted above.

As this is a rather important point, I think, in clearing the way for Fraunhofer diffraction, let me include from Horn-D'Arturo's research

(but utilized by him quite otherwise), the following authoritative observations:

Mannheim: "About a minute before the disappearance of the light . . . some very faint fringes appeared until the moment of occultation. The fringes were at first separated by about 1 decimeter; they later became closer together" (*Ann. de Chemie et Phys.*, 3 Ser., 1860, 208).

Norman Lockyer: Width of the space—"The observers agree that these were very variable, much larger, 4 to 6 inches, at the first appearance of the bands, and decreasing to totality, when they about equalled the bands." . . . "At the end of totality they were small, as at the commencement of totality, and gradually increased in size until the bands were actually intermittent" (*M.R.A.S.*, App. to Vol. LIV, 180).

C. E. Gillette: "Without having made special observations of the point I should say that the shadows were of about the same degree of density throughout their entire appearance, the background upon which they were cast growing gradually darker until the moment of totality, when they entirely disappeared" (*Publ. of the U. S. Naval Obs.*, Sec. Ser., Vol. IV, App. I, D 86).

R. W. Wood: (*ibid.*, D 115), (See Part III).

C. A. Young: "As totality approached, the interval between the bands diminished, till they were only an inch or two apart" (*Aph.J.*, XII, 80).

C. A. Machado: "The width of the dark bands was very variable, appearing when at the narrowest to be a centimeter or a centimeter and a half, but near the moment of totality when better able to be observed, they appeared with a width of 3 or 4 centimeters and separated from each other 6 to 7 centimeters" (Total Eclipse of the Sun of February 3, 1916, Caracas 1916, p. 30).

Accounting for the Slow Speeds

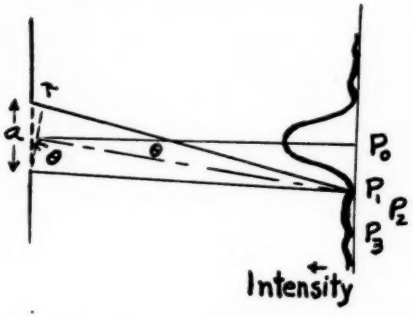
The greatest obstacle to the development of a diffraction theory in the past has been the enormous discrepancy between the speed of the bands and the speed of the lunar shadow. Bigelow was quoted in Part III, summarizing this feeling on the part of scientific men. I surmounted this objection in my 1935 paper and my solution at that time is better supported now by the accumulated data, as will be shown. I set the equation for Fraunhofer diffraction from a slit, which, expressed by Jenkins and White is

$$d = f\lambda/a$$

Here d is the separation between bands, a is the width of the solar crescent, λ is the wave-length of the light causing the bands, and f is the distance from moon to earth and corresponds to the focal length of the laboratory lens employed to render the rays parallel.

Examining the equation, one can see that a decrease in the value of a, the slit width, should increase the separation of diffraction bands. At any one instant, the diffracted light reaching an observer gives one pattern; a moment later the width of the solar crescent emitting the light is different, hence the pattern is different. It would produce an effect as though one were watching the folds of an accordion bellows while restricting his field of view with a small frame. One moment the folds are widely separated, the next they are closer together, this having been accomplished by moving one hand perhaps a foot, whereas the individual

folds will have moved but a portion of an inch each, though in the same time and at a consequently slower velocity.



Angle of first minimun of single slit diffraction pattern.

FIGURE 1

The following table is copied from my 1935 paper, made up on assumptions which seemed satisfactory at that time.

VELOCITY DUE TO "CLOSING SLIT"

Interval before 2d contact	Band width	Separation	Total distance	Number of bands per kilometer
2 minutes	1 inch	6.5 inches	7.5 inches (19 cm)	5263
0 minutes	1 inch	5.5 inches	6.5 inches (16.5 cm)	6060
			Change in band "frequency" in 2 minutes	797 per km.

1 Km : 6060 bands

5263 : 797

Velocity = 797/6060 km per 2 minutes
= 0.13 km per 2 minutes
= 3.9 km/hr. or 2.4 miles/hour.

In order to crowd in the additional 797 bands, the 5263rd band must have been moved through 0.13 Km in the 2 minutes interval. The consequent velocity of 2.4 miles/hr. takes no account of the total width of the band zone. Furthermore, thinking of the accordion analogy, the varying velocity of each band must be different from that of its fellows. As the separation steadily shrinks, the velocity steadily increases, though the increase is at a slower and slower rate. This theoretical deduction, it will be observed, fits with the observations described on a previous page.

Quoting myself again: "If we change the assumed values of width and separation only very slightly, we obtain appreciable differences in the rate of progression, all of which are within the limits reported by observers."

Band width	Separation varying	Total	Calculated speed
1 inch	From 6.5 to 5.5 inches	7.5 to 6.5	3.9 km/hr. 2.4 mph
1 inch	7 to 5 "	8 to 6	4.7 "
(varying width) 0.5 to 1.5 inch	6 to 4 "	7.5 to 4.5	7.5 "

Note that a slight change in band width or separation, or in both, causes an appreciable band speed, which is independent of the speed of the moon's shadow on the earth. This should surmount one of the chief objections to a diffraction theory illustrated by Bigelow's remarks.

Employment of the diffraction equation yields a very interesting result, shown by the accompanying table. The moon distances, taken to the surface of the earth, are the minimum and maximum and their mean at the eclipse position. I started to use 4000, 6000, and 8000 A as the wave-lengths, but, noting in Lockyer's table (to follow) that the strongest arc lines in the flash spectrum were reported to be 4307.96 and 4325.92 A, with calcium nearby with 4226.9, I made the calculation for 4300 A instead of 4000. The separation of bands, *d*, was taken at 6 cm, because this figure is specifically given by Machado in one of the quoted reports as the minimum distance a moment before totality, and because many other reports give a separation nearly the same. Miles and kilometers are both used, miles by preference because of American usage, kilometers because of the simple connection with the Angstrom unit.

f miles (Young)	*x* (A) times 10^{-8}cm	*d* (cm)	"Slit width" *a* calculated	Ratio solar to lunar distance	Height in solar atmosphere		Subtended arc
220,000	4300	6	2.54 Km	422	1071 Km	664 mi.	
	6000	5	3.52		1485.4	923	
	8000	6	4.70		1983	1232	
226,850	4300	6	2.61 Km	410	1072 Km	666 mi.	1".46
	6000	6	3.62		1484.2	922	
	8000	6	4.82		1976	1228	
235,000	4300	6	2.69 Km	395	1062 Km	660 mi.	
	6000	6	3.75		1481	920	
	8000	6	5.00		1975	1227	

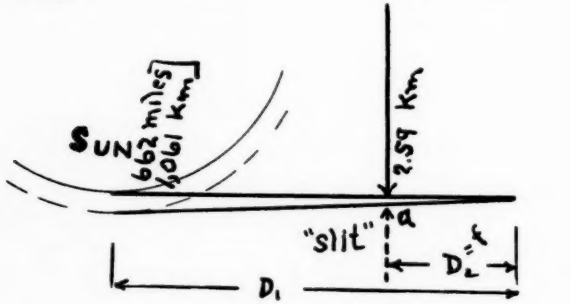


FIGURE 2

Illustrative calculation:

$$a = \frac{(235{,}000 \times 1.609 \times 10^5)\ (4.3 \times 10^{-5})}{6 \times 10^5}$$

$$= 2.69 \text{ km.}$$

Other values of the separation, *d*, are not employed because the least distance is the only one which can fit into the proportion with the value of a single wave-length in the similar triangle solution.

Compare the above table with the following data from Lockyer, based upon the length of the arcs in a flash spectrum:

Lines	Length of arcs	Height in photosphere Miles	Seconds of arc
Calcium, K	130°	6000	13.3
Hydrogen	112	4500	10.0
Helium 4471.25 A	105	4000	8.9
Helium 4026.3 Strontium 4077.9 and 4215.66	86	2700	6.0
Calcium 4226.9; unknown 4247	72.5	2000	4.4
Magnesium ultraviolet triplet, strongest arc lines, 4307.96, 4325.92, etc.	60	1450	3.2
Aluminum 3944.16 and 3961.67; iron enhanced lines 4584 and 4233; manganese quartet 4030.9, etc.	51	1100	2.4
Iron enhanced quartet 4523, etc., and many other lines	40	650	1.4
Carbon fluting and many lines, including arc lines of iron	35	475	1.05

(Table copied from my notes.—R.L.F.)

Note the coincidence between the calculated height of solar atmosphere corresponding to the "slit width" at the moon, and the height in the solar atmosphere, according to the flash spectrum, of vapor possessing nearly the wave-length employed in the calculation,—namely Lockyer's iron, 4523 A. The height reported was 650 miles. (In 1929, St. John ascribed to "Fe 10" a height of 1,000 kilometers, or 625 miles.) Employment of 4300 A yields about 660 miles, equivalent to a subtended arc of 1".46.

Having found in 1935 how the direction of progress of the bands may be referred to the nearer edge of the moon's shadow, and that the directions in this respect may be completely reversed at some points of observation, I sought for two or more velocities, varying in magnitude, but in the same line of direction, which might be composed into the observed velocities. In addition to a velocity imparted by a closing or opening of the "slit" as described above, I resorted to a lifting or falling of the moon with respect to the earth such as one might visualize if he recognizes the continual change in distance between earth and moon. This seemed a helpful idea. Thus the shadow-cone would rise or fall with its mantle of bands. The path of totality would thus widen or narrow as the shadow-spot expanded or contracted. A change in the altitude above sea-level could produce a similar effect; and the change in latitude on the earth with consequent change in "penetration" of the shadow would similarly raise or lower points on the earth's surface with respect

to the shadow, just as though the lunar distance were changing as at first suggested.

After graphically representing the 1925 band directions on a map, I included in a report to Professor Humphreys the following: "The band directions across New York State lead me to say the moon was at apex of its curving path until a point was reached between Poughkeepsie and New Haven. Not only was it at the 'apex' but it was steady as far as vertical motion is concerned. Now, because of the New Haven reports I would like to give the moon a 'perturbation' (whatever that is) over this point. I need to have it jump up a little just after totality (with a slight fall also before totality there). Either that, or I need another component velocity. After that point . . . we have a 'falling moon,' bound on its course towards the 'first quarter' node."

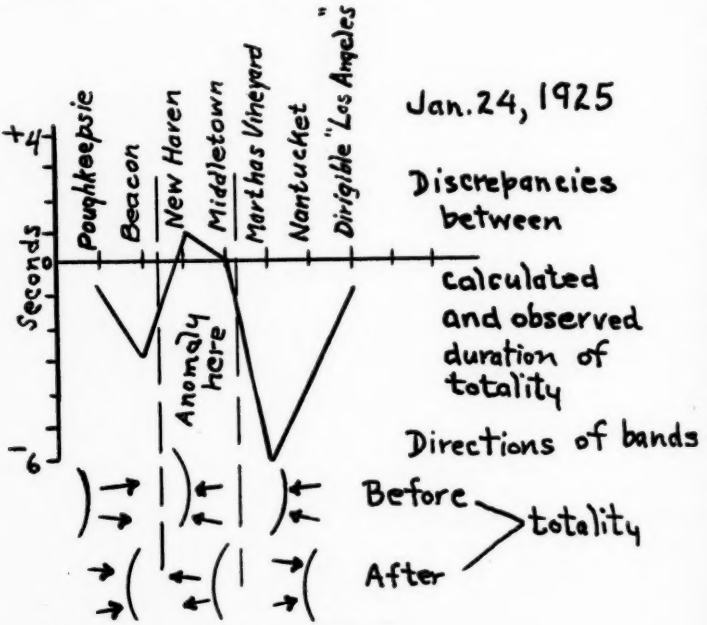


FIGURE 3

My summary of these bands in Part I of this series segregates the New Haven area (Bridgeport to Saybrook Junction) into a special area, about one-half degree wide, where the character of the band display was distinct and different from the whole region west or the region east to the limits covered by observers.

My jumping moon is as bad, I realize, as Newton's fits of easy reflexion and easy transmission ascribed to light. Nevertheless, I am interested to read that Hansen assumed a difference between the center of

mass and center of figure of the moon, and that Brown has shown that the northern half of the moon is probably denser than the residue, ideas which would lead to a wobble, and a wobble is as good as,—or as bad as, —a jump. And in addition, I find the following table in Mitchell's "Eclipses of the Sun," showing the discrepancies between the predicted and observed durations of that 1925 eclipse.

Place	Duration
Poughkeepsie, New York	—0^s.8
Beacon, New York	—2.9
New Haven, Connecticut	+0.8
Middletown, Connecticut	0.0
Martha's Vineyard, Massachusetts	—6.
Nantucket, Massachusetts	—3.7
Dirigible *Los Angeles*	—0.9

In testing different factors which might provide component velocities to be composed into the band velocities reported, I have had in mind the three cases of stationary bands mentioned, the positions at which observed serving as "critical points."

The latitude of Canton Island is about S 3°. The radius of a section through the earth at right angles to the axis is here 6,369 km and the circumference is 40,020 km. The tangential velocity is therefore

$$v = 40{,}020 \text{ km}/86{,}400 \text{ sec. or } 0.46 \text{ kilometer/sec.}$$

With respect to a line considered fixed in space, for example a meridian on the celestial sphere,—one may calculate components of this velocity. By reference to the diagram I prepared and issued to Professor Mitchell along with my predictions as to band direction, I find I predicted the pretotality bands would move (*if* they moved) in the direction N 35° E or its reciprocal, the opposite direction. As reported by Captain Hellweg, his eight men described the bands as stationary and extending "in an east-west direction." The compass declination thereabouts is 5° E (approx.) ; and a reasonable leeway is legitimate from the manner of description of the direction. Permitting myself the liberty of taking a normal to the stationary bands in the direction 30° east of north (or 60° north of east), I calculate a component of the earth's tangential velocity as follows:

$$v_e = v/\cos 60° = .46 \text{ km per sec.}/.5 = .92 \text{ km per sec.}$$

What was the latitude of the portion of the sun's disk which was projected on Canton Island at the edge of the moon's shadow before totality when the stationary bands were seen? Knowing only that the solar equator slants with respect to the plane of the ecliptic by about 7°, and lacking precise knowledge of its position, I have drawn a North and South line through the elliptical shadow spot, a bisecting line at right angles for the heliographic equator, and from the intersection a radial line to determine the heliographic latitude desired.

From Mitchell's book I obtain the following mean values reported for

the period 1901-13, for each five degrees of heliographic latitude:

Lat.	0	5	10	15	20	25	30	35	40	
Km/sec.		2.02		1.93		1.77		1.54		
	2.04		1.99		1.86		1.66		1.42	
Lat.	45	50	55	60	65	70	75	80	85	90
Km/sec.		1.14		0.84		0.55		0.27		...
	1.28		0.99		0.70		0.41		..	

My component of the earth's tangential velocity, 0.92 km/sec., is matched by the velocity of a point on the edge of the sun at a heliographic latitude between 55° and 60°. The radial line, drawn on the diagram of the elliptical shadow spot and making an angle of 57° with the equatorial line, strikes the border only slightly north of the location assigned to Canton Island. Here, then, is another remarkable coincidence.

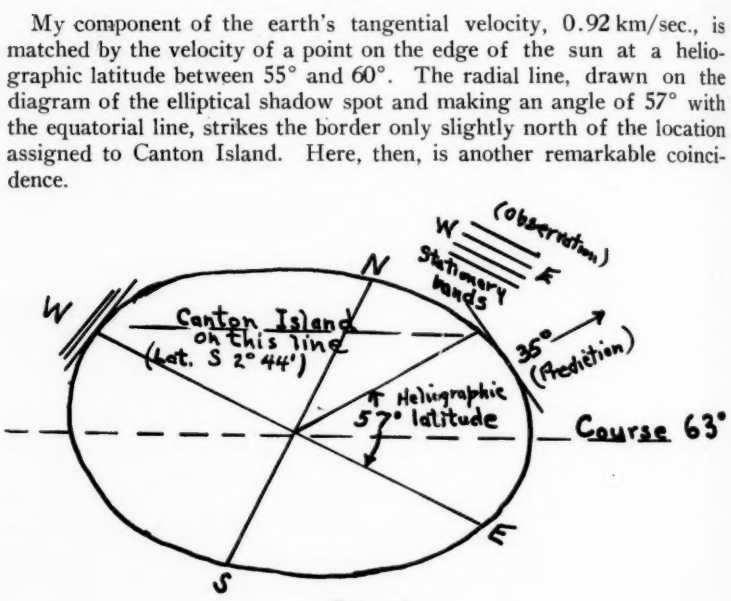


FIGURE 4

When applied to the velocity following totality, namely, towards the west at 10 feet per second or more, neither addition nor subtraction of the components works. The band direction being west both by observation and prediction, the earth's tangential speed in the East-West line is 0.46 km/sec. as calculated above. The portion of the solar rim projected over Canton Island just after third contact was between 0° and 10° South in heliographic latitude, the velocity being about 2 km/sec. Ten feet per second is about 3 meters or 0.003 km/sec.

On the other hand turning to the stationary bands at Fort de Kock in Sumatra in 1901, agreement between the respective velocities is found for both displays. The eclipse occurred on May 18, and was total over Sumatra not long after mid-day. At that season, with the sun well north of the equator, the projection of the shadow lay over Sumatra as an ellipse with its longer axis slightly west of north. The latitude of Fort de Kock is S 00° 18′. The earth's tangential velocity there would be

0.463 km/sec. Fort de Kock was chosen as one eclipse site because it was on the northern edge of the track. The angular situation before totality at Canton Island is duplicated almost exactly. A tangent to the shadow before totality represents the shadow bands. A normal to such a tangent drawn at the approximate position of Fort de Kock points about 60° north of east and the calculated value of the component of the earth's tangential velocity in this direction is 0.93 km/sec. The projected heliographic latitude is somewhere near N 60° as at Canton,—(hence, solar speed between 0.84 and 0.99 km/sec.)—and in other words there is again equality of the two component velocities. Their algebraic difference is zero. The situation after totality at Fort de Kock was almost identical with that before totality and apparenly an identical condition as to band motion was observed.

FIGURE 5

On August 30, 1905, at Alcala de Chiver, on the Mediterranean coast of Spain, stationary shadow bands were reported by Moye in POPULAR ASTRONOMY, XIII, 524 (according to Horn-d'Arturo). I cannot account for them and have not read the original report. D'Arturo says they were stationary, but gives the "azimut dell'apice osservato" as SE both before and after totality. Taking the city as located on the centerline or nearly so, the totality occurring near 1:00 P.M., the direction of progress, if any, should have been as indicated both before and afterwards (or else the reverse direction). But if there was enough motion to suggest the direction reported, then the bands were *not* stationary.

Any other reports of stationary bands known to readers will be thankfully investigated if called to my attention.

It will be recalled that Richard's report in Part I, specifies that the bands near the northern border after totality had about twice the speed of those before totality. That ellipse pointed towards the southeast, close to 135° at Newport. Before totality the component of the earth's velocity

would be large, relative to the component afterwards; while the velocity of the sun at the heliographic latitude projected would also be less in the latter case than in the former. If the drop in the one component was in a different amount from that in the other, there would be a difference in the resultant corresponding to that observed. The components of the earth's velocity would approach very closely the solar velocities at Newport.

When one considers this matter of the earth's tangential velocity, he notes that the velocity must decrease as the earth latitude increases. Considering any one heliographic latitude, such as the sun's equator, projected upon some one portion of an eclipse path—as the center-line—in any part of the earth, it might be expected that the difference between the two, or the resultant velocity, would become greater with increase of latitude. I have re-examined the tables published by D'Arturo, and find what I had looked for previously but missed through inadvertence.

In his Table IV, taking in band reports from 12 eclipses, he includes 25 separate observations from the 1900 eclipse (not including a report of mean values of the reports collected and analyzed by Bigelow). Twelve of the reports, from 9 different locations, specify band speeds. The eclipse path extended north-easterly through the Southern States, crossed the Atlantic, and then pursued a southeasterly course through Spain into Africa. I have averaged the speeds of the two reports from each of three towns. The least precise estimate of speed was that of

ECLIPSE OF MAY 28, 1900

(From D'Arturo's Table IV. Analysis by R.L.F.)

Location, authority, source	Latitude	Speed meters/sec.	
Barnesville (Chappell), *Publ. U. S. Naval Obs.*, Vol. IV, App. I D 85	N 33° 03′	1.53	
Barnesville (Gillette), *ibid.*, D. 86		1.07	
		Mean	1.30
Wadesboro (Coleman and 8 others), *ibid.*, D 170	35° 00′	0.61	
Wadesboro (Reilly, Erdman, Mayer), *Aph. J.*, XII, 77		2.23	
		Mean	1.42
Kelford (Various observers), *ibid.*,* D 174	35° 40′	3.05	3.05
Ahoskie (Tornburg), *ibid.*, D 173	36 17	(10-20 ft./sec.)	(3.9-)
Virginia Beach (Putnam), *ibid.*, D 184	36° 50′		4.12
Point Breeze (Loomis), *ibid.*, D 181	36 58		5.34
Estarreja (Marsden), "The Total Solar Eclipse of 1900," E. W. Maunder, p. 172. (A summary?)	40° 45′	(13.50)	....
Manzanares (Moore), *ibid.*, 170	39 00		2.90
Elche (Williss), *ibid.*, 165	38° 16′	3.13	
Elche (Moye), *B.S.A.F.*, 1900, 136; *C.R.*, CXXX, 1699, Maunder I, c, 167		1.55	
		Mean	2.39
Algeri (Brook), Maunder I, c, 167	36° 48′		1.37

**Publ. U. S. Naval Obs.*, Vol. IV, App. I.

Tornburg at Ahoskie, quoted as between 10-20 feet/sec. In the second column I have scaled this down to 13 feet/second, and omitted the report of Marsden at Estarreja. D'Arturo struck the averages and made the conversions from the reported miles per hour or feet or yards per second, into meters per second, with the exception of the report of Moye at Elche.

Considering the difficulties of observers, unequipped with speed measuring devices, confronted suddenly, and for not more than a couple of minutes, with a rapid movement of more or less pale shadows, probably seen for the first time, is it not remarkable indeed that the averaged reports, treated in a purely statistical way, show a regular increase and decrease with increase and decrease in latitude,—and in accord with a speculation which has yielded other interesting results? (Note the latitude of the two places having stationary bands.)

The speed of the various points on the edge of the sun are known through the application of the Doppler principle in spectrographic studies. Why there should be a connection between the Doppler effect and the band speed I cannot imagine. Perhaps it is an illusion,—or pure coincidence. Who knows? I have considered many other possibilities in trying to account for the bands. To obtain the concentric ring effect and still accommodate the refractionists, I thought of the tidal bulge in the atmosphere. In place of interference bands by diffraction I considered the Lloyd's mirror effect. There was the gravitational effect of the moon on the light passing its edge, as well as the Einstein effect. Ascension of solar vapors, and a pinhole camera action past the moon's edge; the rotation of a beam of light by a revolving mirror,—the moon; —these, and perhaps some other solutions have suggested themselves. The grist has been to the mill and in summary of the outcome, I can say of my work that it:

1. Establishes definitely, through my predictions for 1936 and 1937 and by analysis of records, that shadow bands are concentric with the lunar shadow;
2. Shows coincidence between the anomalous behavior of the 1925 bands in the New Haven area and an anomaly in the deviation of eclipse durations from predictions for New Haven and Middletown;
3. Explains the insufficiency of current band theories;
4. Indicates how diffraction can account for shadow bands;
5. Suggests that the special iron state in the photosphere, called "Fe 10," may be associated with the bands;
6. Accounts for band directions and speeds in terms of a composition of velocities, supported by evidence that the observed speeds increase with increase of latitude, as required;
7. Accounts for two definitely established cases of stationary bands;
8. Connects the rotational velocity of the earth with that of the sun;
9. Associates the Doppler effect with the bands by an intermediate action to be sought after; and

10. Is offered to the physics and astrophysics fraternity as of possible utility in the solution of various problems involving light, relative motion, and lunar theory.

ROOSEVELT HIGH SCHOOL, WASHINGTON, D. C., APRIL 21, 1940.

John Churchill Hammond

John Churchill Hammond was born June 3, 1871, in Livingston County, Michigan. He attended the Universities of Michigan and Chicago, receiving the degrees B.S. and M.S. in 1894 and 1896. In 1898 he joined the staff of the Nautical Almanac Office, in Washington, under Professor William Harkness. The Office had become a part of the Naval Observatory a few years earlier, and in 1900 Hammond, who had evinced a desire to use the astronomical instruments, was transferred to observing duties. For a few years he was assigned to the 26-inch equatorial, chiefly for satellite and double-star measures, and in 1911 he was placed in charge of the 6-inch transit circle. His principal work thereafter was in the field of meridian astronomy.

A program consisting of fundamental observations of the Backlund-Hough stars occupied the period 1911-1918. These observations formed a considerable part of the basis of Eichelberger's well-known catalogue of standard stars. Observations of the sun, moon, planets, Gill's list of zodiacal stars, Eros comparison stars, and further lists of standard stars, were among the later tasks of Hammond and his associates. Hammond was an accurate and painstaking observer and his skill in discussing observational material was outstanding.

In 1911 he married Lillian Gordon; he retired January 1, 1934, and died at St. Petersburg, Florida, May 11, 1940.

C. B. WATTS.

U. S. NAVAL OBSERVATORY, WASHINGTON, D. C., JUNE 24, 1940.

The Total Solar Eclipse of October 1, 1940

By LEWIS J. BOSS

This eclipse is noteworthy for several reasons. For instance, it is the thirteenth return of the eclipse observed by Cassini in 1706, who made the first recorded observation of the corona. He was under the impression that this "crown" of pale light was caused by the illumination of zodiacal light. The red hydrogen prominences were also noted for the first time, apparently, at this eclipse, by Stannyan who wrote a description of the "red flames" to Flamsteed.

On June 24, 1778, seventy-two years later, another total solar eclipse, in this same series, was observed by the Spanish Admiral Ulloa, who

thought the prominences must be the sun's light shining through some hole or crevice in the limb of the moon. This eclipse, incidentally, was the first total solar eclipse to be carefully observed in the British-American Colonies. David Rittenhouse of Philadelphia made the observations, thus preceding the eclipse party sent out by Harvard University, under Professor Samuel Williams, to observe the total solar eclipse of October 27, 1780, by two years.

Observations made on still another solar eclipse in this cycle, on August 18, 1868, revealed the chemical constituents of the "red flames" to Janssen, who observed them with the spectroscope, both during the eclipse and subsequently. Lockyer and Huggins confirmed Janssen's observations on October 20, 1868, working independently, without benefit of an eclipse.

Herewith are given the dates of the beginning and ending of the partial eclipses, the date of the first central, the date of the change from annular to total, date of middle eclipse of the series, dates of total eclipses of longest duration of totality on the central line, date of last total eclipse, and date when the series ends.

1. The first partial eclipse of this series took place on July 13, 1219, and was visible only in high northern latitudes.

2. The first central, and annular, eclipse occurred on November 30, 1453.

3. The series changed from annular to total on February 3, 1562. The moon's mean anomaly, 57° 22′ 12″; the sun's, 47° 55′ 12″. The moon's shadow just touched the earth.

4. The middle eclipse of the series took place on September 9, 1904, the moon then being close to its ascending node (☊), the argument of latitude being only +0° 11′ 31″. All of the eclipses in this series take place at or near the moon's ascending node and each successive path of totality gradually moves south.

5. The three eclipses having the longest duration of totality on the central line took place on July 16, 1814; July 27, 1832; and August 7, 1850. At some points on the central line the duration of totality was nearly seven (7) minutes.

6. The last central eclipse will occur on June 21, 2373, and will be total, but the duration of totality will be short.

7. The series will entirely run out on September 11, 2517, with a very small partial eclipse. The northern limb of the moon will just a little more than cover the southern limb of the sun. This partial eclipse will be visible only in high southern latitudes.

North Scituate, Rhode Island, November 25, 1939.

A Method of Estimating the Absolute Number of Meteorites*

By BEN HUR WILSON

While meteorites have been seriously studied by scientists for nearly one hundred and fifty years, they now occupy the unique position of having raised more questions than they have solved. One of the liveliest, and, at the same time, the most important and controversial of all such problems concerns the number of falls, as well as, the amount of meteoritic accretion coming to the earth's surface within a given unit of time. Due to the very complex nature of the criteria employed in the attempted solution of this problem, there now seems to be so much discrepancy and uncertainty involved in all such estimates that any new suggestions promising to throw additional light upon the subject should be welcomed by all students of meteoritics.

This problem, we find, has already been attacked from almost every conceivable angle, and estimates of both their number and total mass have varied within wide range. Indeed, some theorists have contended that almost our entire earth was built up, little by little, about a central nucleus of comparatively small diameter, by the accretion of meteoritic material, swept from space over long eons of time. On the other hand, it has been estimated by some of our ablest research workers that, at the present rate of infall, only a few millimeters of thickness would be added to the earth's diameter in one hundred thousand years, a fact which must discredit, at least partially, the so-called planetesimal theory, above mentioned.

Definitions

Before launching into any serious discussion of the details concerning the hypothesis which we herein propose to set up, it may, perhaps, be well for us first to define carefully some of the terms which we must frequently employ in our effort to elucidate certain phases involved in the problem being considered. This will establish a common background of thought, so that when any term is mentioned, we may all have the same thing in mind. Lack of such clarifying definitions may often lead to confusion and misunderstanding, and, perhaps, even jeopardize such agreement as might otherwise be reached respecting our final conclusions.

While we are all agreed that one stone makes a *fall,* and many a *shower,* perhaps, we should add that two stones falling simultaneously

*An excerpt from a paper presented by the author, on "The Benld Meteorite" before a joint meeting of the *Society for Research on Meteorites* and *Section E,* at the Columbus (Ohio) meeting of the *American Association for the Advancement of Science,* on December 29, 1939.

should be called a *double-fall,* and three a *triple-fall,* rather than a shower, which term we would reserve for as many as four or more meteorites falling together as a single group. Nininger, in his records, classifies witnessed meteorites as *falls,* and unwitnessed ones, (whose time of coming is unknown), as *finds,* to which we would like to add the term *recovered,* for those not actually witnessed, but whose date of fall is known.

When speaking of meteoritic density, we have in mind the ratio of area to number of all meteorites, including falls, recoveries, and finds, which have so far been gathered in a given region. For the whole number of meteorites (theoretical), which have ever occurred in any area either as falls, finds, recoveries, or unknowns, we shall use the term *absolute number.* The *relative number* which may be high, low, or medium, we shall consider as the ratio between the *absolute number,* the *known number.* To these simple definitions we would add the term, *strikes,* to designate those meteorites which are known to have struck buildings, or other man-made objects, exclusive of highways. This is a term which we shall use rather frequently throughout the discussion which is to follow.

An Analysis

List of Known Strikes*

(1) 1790—Barbotan, France
(2) 1798—Benares, India
(3) 1803—Mässing, Germany (Bavaria)
(4) 1847—Braunau, now Germany (then Bohemia, and recently Czechoslovakia)
(5) 1858—Aussun, France
(6) 1863—Pillistfer, Latvia (then Russia)
(7) 1911—Kilbourne, Wisconsin, U.S.A.
(8) 1916—Baxter, Missouri, U.S.A.
(9) 1930—Kurumi, Japan
(10) 1936—Yurtuk, Ukraine, U.S.S.R.
(11) 1938—Benld, Illinois, U.S.A.

We have here a list of eleven well-authenticated instances, comprising all meteorites which are positively known to have struck buildings. It will be noted that these strikes are located in widely scattered regions, and over a time interval of approximately one hundred fifty years (1790-1938), or one "strike" on hte average to every 15 years.

Let us carefully examine these data and see if any significant conclusions may be drawn therefrom. In the first place, we shall immediately grant that these are random falls; and also that there is more than an even probability that the list is not complete,—doubtless there have been more than eleven strikes during this period, within this same region. How many more, will never be accurately known.

However, neither of the two suppositions above pointed out, need de-

*Prepared by Dr. Henry W. Nichols, Curator of Geology, of the Field Museum of Natural History, Chicago; and published in Vol. 10, No. 2 (Feb. 1939) of the *Field Museum News.*

tract from the validity of our hypothesis, which is to be stated later. At most they can only alter the final estimate, and that, largely in the direction of the positive side. It must be remembered that buildings everywhere are also located at random, and where we have random distribution of falls making direct hits over random locations (buildings), the probability of a valid or a reasonably accurate average is thereby greatly enhanced.

Now, in regard to the number of strikes, we shall assume only those which are positively known, and should we concede that there may have been others which have probably been missed or overlooked, then this factor, if it were to be accepted, could only increase the value of our final estimate of absolute falls; for by no sane process of reasoning that we know anything about could it possibly diminish it. In other words, all final estimates arrived at by this process, we shall later see must be considered as values which are, for the most part, positive-plus.

Let us once again examine our list, discarding all strikes excepting those which have occurred in the United States. This will immediately give us a more definite, homogeneous area upon which to theorize. Here we find that there are three authentic strikes, which have occurred over a period of 27 years; beginning with the Kilbourne, Wisconsin, in 1911; including the Baxter, Missouri, of 1916; and, ending with the Benld, Illinois, of 1938. This would give us for this region an average time interval of one strike every 13.5 years, well in keeping with our average

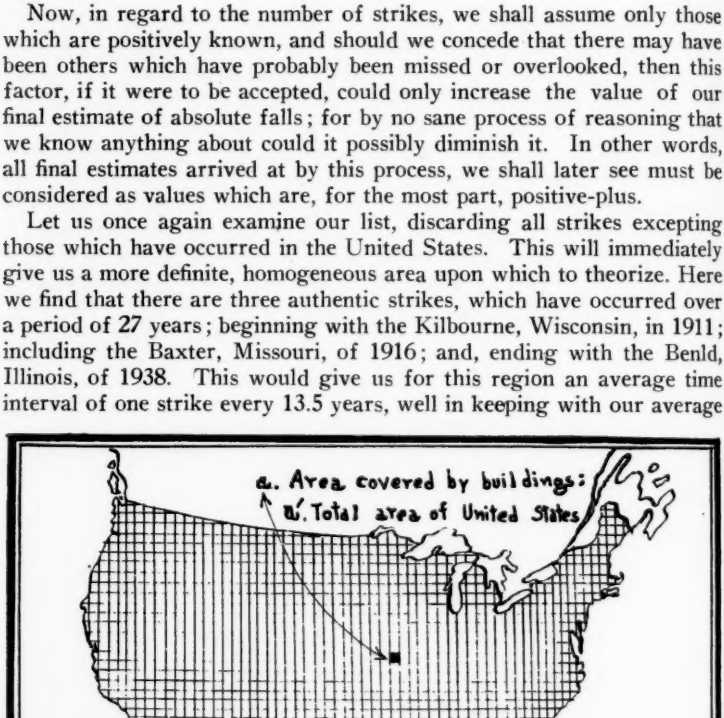


FIGURE 1

Outline Map illustrating the combined area, a, covered by buildings, as compared with the total area, a', of the United States, in the formula, $a:a'::n:x$.
(*n.b.* Areas are not drawn to scale.)

for the entire list. In other words, on the entire area, in the United States, which is covered with buildings, there have occurred at least three known meteorite falls during this period.

An Hypothesis

Since these are random falls upon random locations, we may, therefore, assume the total number of falls, during the same period, over the entire United States, to be somewhere in line with the direct proportion which the total area covered by buildings bears to the total area of the United States. That is to say $a : a' :: 3 : x$, when a equals the total area covered by buildings, and a' the total area of the United States. (See Figure 1.)

Just what this relationship of area covered to total area is, cannot, due to its very nature, be known for an absolute certainty. I have very carefully estimated this factor from a number of angles, and, upon the advice of others who have also given the matter considerable study, have come to the conclusion that, for the present at least, or until we have more definite information, we may assume it to be as 1 is to 2,500. This is probably not in error more than 50% in either direction. Substituting, we then have the proportion $1 : 2{,}500 :: 3 : x$, with 3 being the number of strikes falling on the area covered by buildings, and x the absolute number of falls for the United States, as estimated by this hypothesis. The value for x, it will be seen is 7,500, or we shall say, approximately 250 absolute falls per annum.

Probability of Error

Let us consider for a moment the probability of this being a fairly correct estimate, and also some possibilities of error. First, and perhaps of utmost importance, is our factor the ratio of a to a', (building to total area). Should we concede that 2,500 is too great a number, then let us reduce this amount. Let us even go so far as to cut it in half and call it 1,250 (which is certainly conservative and doubtless much too small). In such event, we shall still have a value of 125 or more falls per year, for the entire United States. On the other hand, should this factor eventually prove to be too small, as many now believe, when they consider those vast undeveloped domains of our western states, where one may actually drive almost all day, seeing scarcely a building of any kind, then our fall number would become increased, perhaps to as much as 1,500 per year.

The next most important question concerns the absolute number of strikes. We are certain, beyond all probability of doubt, that there have been at least three, for all have been well authenticated. As stated, previously, there may even have been others which have thus far escaped our attention. For example, the Baxter strike, occurring in 1916, was a matter of only local knowledge for more than 20 years, when its occurrence was related and thus made known to the scientific world. If such

vital information could lie dormant for so many years, it would certainly be unreasonable to deny the probability of the existence of yet other strikes within the United States, having occurred within the same time period. Should we assume only one such additional strike to have occurred, this would thereupon augment the value of our original estimate of absolute falls by 33⅓%, or several hundred per year, depending upon the absolute ratio of a to a'. It is even thought by some that it is not entirely beyond the range of probability that there may have been as many as double the number of strikes (6) that are now recognized. However, we do not wish it, for a moment, understood that we contend that this supposition is a fact. We simply do not know how many strikes there have actually been, nor does anyone else. By its very nature it will forever remain one of those unknown matters.

While the foregoing speculations are major probabilities, it must be remembered that there are also other minor considerations worthy of mention. A factor, not without some importance, which, we have so far ignored altogether, is the total ground area of the buildings actually struck, compared with that of the total area of all buildings. It is a singular fact that none of the strikes occurred in places having heavy building concentration, such as in large cities or other densely populated regions. Furthermore, all known strikes happened to hit small buildings, perhaps averaging not more than 20 feet square (400 sq. ft.). That is to say, three out of a total of about 100 witnessed falls occurring over a period of about 30 years, or about 1/30 of the whole number, landed on a space of not exceeding 1200 square feet, which happened to be occupied by buildings. It would hardly appear probable that one meteorite out of thirty would by pure chance land in such a manner, for no one would be so unreasonable as to suspect that small buildings have any special attraction for meteorites, (and certainly no magnetic attraction). This is just out of the question. The only logical explanation of this state of affairs is that for every meteorite which is observed and found, there must be a considerable number which are not recovered. How many, is the problem we are here attempting to help solve.

Still another fact to which we have given considerable thought, and wondered why, is that all three of these strikes have been bunched up into a comparatively small area, which might be inscribed within a radius of about 250 miles, being located in the three adjoining states of Wisconsin, Illinois, and Missouri. Here, then, we have what might be thought of as a region where there is a concentration of strikes occurring for no known reason, except the law of chance. Perhaps over a period of 1000 years this particular situation would become entirely reversed, and thus this seeming inconsistency would be ironed out by data accumulated over the much longer sweep of time. Should this tendency of meteorites to strike buildings be inherent and equal over the entire country, there should have been between forty and fifty such strikes, instead of the three which are now known. This in itself is suf-

ficient reason for believing that there may have been yet other strikes which have passed unobserved, or have never been reported upon.

An additional thought bearing upon this matter of location is the fact that all strikes have taken place within a region of low meteoritic distribution, with the possible exception of the Baxter, which is medium. So it cannot be claimed that buildings have here been hit, due to any great concentration of falls in this vicinity. Furthermore, all of these strikes have occurred in the neighborhood of the 40th parallel of latitude, or about half way on the earth's surface, between the equator and the poles, —a fact not without some significance, for this places them in the region where the broadside unit number of falls must be considerably spread, and the unit area number thereby somewhat reduced. (See Figure 2.)

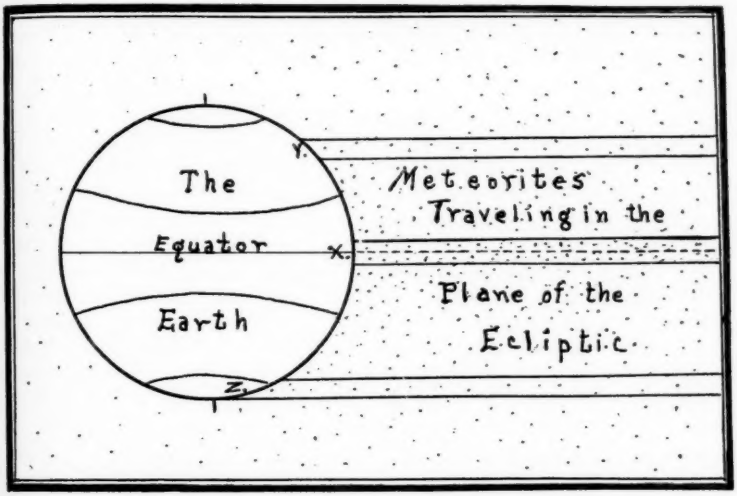


FIGURE 2

DIAGRAM SHOWING EARTH IN THE PLANE OF THE ECLIPTIC.

When passing through unit areas of space:

x. Represents unit of maximum surface density,
y. Represents unit of medium surface density, and
z. Represents unit of least surface density-(tangency)

That is to say, if most meteorites are of solar origin, as is now believed, and are therefore traveling in planes parallel or nearly parallel to the ecliptic, then assuming a fairly even distribution throughout space, coupled with the further equalizing effect of the earth's rapid spinning on its axis, we should expect the greatest density of falls to occur within the Equatorial Belt, and correspondingly fewer falls as we proceed towards the poles on either side. This may readily be explained by the fact that plane unit areas of space, intercepted by the earth in its annual

journey about the sun, would in the vicinity of the equator, (or in places of low latitudes), cover minimum areas on the earth's surface. It necessarily follows that these space units would of necessity spread over increasingly larger areas as we proceed into the regions of progressively higher latitude. We believe this hypothesis to be born out by actual experience, the data for which must be more or less familiar to every student of meteoritics.

If this line of reasoning is not quite clear to the reader, it will help him, if he will remember that the same factor is constantly operating with respect to the sun's parallel rays, which yield far more surface energy at the equator than in the polar regions; for, aside from the directness of their impact in lower latitudes, they are considerably more concentrated in this location, due to the fact that they here cover minimum unit surface areas. They, too, become correspondingly weaker when spread out over larger areas on approaching tangency in polar regions.

And, finally, we should call attention to the fact that in every instance where strikes have occurred, they are the result of single falls, so far as our actual knowledge is concerned, and not of a large number of individuals falling broadcast over a limited meteoritic field. In the event of a great meteoritic shower it would certainly not be unreasonable to expect that some, perhaps several, might hit buildings. That this has not been the case, at least not in this country, has, indeed, been a fortunate circumstance; for, had one or more of our strikes occurred during showers, it would have greatly complicated the issue, so far as our calculations are concerned, perhaps, even beclouding the final results to such a degree that they would be of little or no value. As it is, we may now truthfully say that, under existing circumstances, our data are based on the results of meteorites just falling normally or singly in the ordinary course of such occurrences, and not upon such extraordinary circumstances attendant upon the simultaneous falling of a great number of stones, barrage-like over a comparatively small area. The relationship of the number of single falls to showers is fortunately a matter that need not greatly concern us at this point or disturb our present calculations.

Summary

Now let us restate our hypotheses, and review briefly the supporting evidence. We contend that *the number of meteorites striking buildings, within a given time unit must bear some relationship to the total number of absolute falls within a given area.*

Clarifying, the number of meteorites (n) known to strike buildings is to the absolute number (x) of falls, as the total area (a) of all buildings is to the total area (a') of the United States, *i.e.*, $a : a' :: n : x$. Assuming the ratio of a to a' to be of the order of 1 : 2,500, then by substitution we have $1 : 2{,}500 :: 3 : x$, which gives us a value of 7,500 for x, the number falling in a period of approximately thirty years, or at the

rate of about 250 individual falls per year.

Examining the evidence bearing upon the validity of these premises, we have to consider: (1) The *ratio a to a'*. This assumed ratio of 1 to 2,500 may be either too large or too small a number, and may therefore affect the validity of our result in either direction. So we shall say, that this item may operate either *positively* to increase our final results, or *negatively* to decrease it. (2) *Number of falls.* Cannot be smaller than that assumed, and may be larger; influence *positive.* (3) *Did not strike in cities, or hit large buildings.* Since there would be a greater probability that strikes would occur in places of greater building concentration, or on the larger type of buildings, the fact that only small buildings were hit, and that in isolated locations, is a factor favoring validity on the *positive* side. (4) *Strikes did not occur in regions of high meteoric distribution.* This must be considered as a *positive* factor, since there is greater probability that building will be struck where the frequency is highest. (5) *All strikes have occurred in regions of medium latitude,* somewhere about 40°. This region being above that where ordinarily we would expect the greatest meteoric density, it is obvious, therefore, that this point if considered must also be classed as a *positive* factor. (6) *No strike has to our knowledge ever occurred during a so-called meteoric shower.* Since there would be far greater probability that a building would be hit during a shower, while many stones were falling, than in the event of only a single fall, the fact, nevertheless, remains that all known strikes, at least those under consideration in this paper, have taken place as the result of a single stone dropping from the heavens. This fact must greatly increase the probable validity of our assumption, and thereby becomes a *positive* factor.

In support of the validity of our final estimate, we now present a résumé of the following modifying factors, which may affect our final results, by either decreasing or increasing the value of the probable absolute number of falls per annum.

1. Factor may be either *positive* or *negative.*
2. Factor may be only *positive.* Validity good.
3. Factor may be only *positive.* Validity good.
4. Factor may be only *positive.* Validity good.
5. Factor may be only *positive.* Validity doubtful.
6. Factor may be only *positive.* Validity good.

On the whole then it must be granted that the chances of the absolute number of falls being more than that of the estimate given are greater than that they will be less. How much greater is a question, which, by its very nature, will never be positively known.

Doubtless some may be of the opinion that three strikes are too few upon which to base an hypothesis or to build up any definite conclusions. Personally, I do not think so. One strike might be an accident, and two a coincidence, but where we have three strikes coming under the circumstances above related, *that is positive information.* There must be some discernable law in operation here, and I feel that we should strive

to take advantage of it, as a factor helping us in the solution of this very vital question.

If this be pure chance, then it is chance in the face of some five or six definite and positive obstacles. To pass over the entire matter by saying that these are only random falls, wholly irrelevant to the problem, would be simply a matter of dodging the question by means of a smoke screen; and, surely no true scientist would ever pass on such likely evidence in so light a manner as this.

JOLIET ASTRONOMICAL SOCIETY, JOLIET, ILLINOIS.

Planet Notes for September and October, 1940

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. Apparent positions of the sun are as follows:

	α	δ
	h m	° ′
September 1	10 40.1	+ 8 25.5
October 1	12 28.1	— 3 2.4
November 1	14 24.2	—14 18.9

During the first half of September the sun will be moving through the constellation Leo. On September 15 it leaves Leo and enters the constellation Virgo, through which it will be moving until October 30. On the latter date it enters the constellation Libra. The sun will reach the autumnal equinox on September 23, $4^h\,46^m$, at which instant the season of fall begins.

Moon. Phenomena of the moon will occur as follows:

		h m
New Moon	Sept. 2	4 15
First Quarter	8	19 32
Full Moon	16	14 41
Last Quarter	24	17 47
New Moon	Oct. 1	12 41
First Quarter	8	6 18
Full Moon	16	8 15
Last Quarter	24	6 4
New Moon	30	22 3
		h
Perigee	Sept. 3	6
Apogee	18	8
Perigee	Oct. 1	16
Apogee	15	10
Perigee	30	4

Eclipses. A total eclipse of the sun will occur October 1, 1940. The path of totality begins in Columbia, and passes into the Atlantic Ocean at Pernambuco (Recifé), Brazil. The eclipse track crosses the Atlantic Ocean, and Cape of Good Hope, South Africa. The duration of totality at Pernambuco is $4^m\,51^s$. In South

Africa the total eclipse will last about $3^m\ 30^s$, although this value is subject to considerable variation from the west to east coast.

A small scale chart of the eclipse track, taken from the *American Ephemeris and Nautical Almanac* for 1940, was reproduced in the January, 1940, issue of POPULAR ASTRONOMY, page 24. A *Supplement to the American Ephemeris,* 1940, entitled "Total Eclipse of the Sun, October 1, 1940," for sale ($1.50) by the Superintendent of Documents, Washington, D. C., U.S.A., gives complete astronomical data on the eclipse. Meteorological data for South Africa are also included in the *Supplement,* as well as two large scale maps, in color, of South America and Africa, respectively, showing the eclipse track and data. Another monograph on the eclipse data, "Supplement to the *Nautical Almanac for 1940,*" prepared by the British Nautical Almanac Office, is available, giving full details of the eclipse path, and instructions for the adjustment of instruments near the central line.

An article by Lewis J. Boss, discussing points of historical interest in connection with the series of solar eclipses of which the eclipse of October 1 will be a member, appears in this issue.

A penumbral lunar eclipse, which, however, will be quite unobservable to the unaided eye, will occur on October 16. Circumstances of this eclipse, as furnished by Alexander Pogo, are reproduced in the January, 1940, issue of POPULAR ASTRONOMY, page 23. Dr. Pogo's article, "The Penumbral Lunar Eclipses of 1940," appears on page 6 of the same number of POPULAR ASTRONOMY.

Mercury. Mercury will not be conspicuously visible during most of September. The planet reaches superior conjunction with the sun on September 6, after which date it is an evening star for the duration of September and through the entire month of October. It will reach a greatest elongation as an evening star on October 20, 16^h, when it will be situated 24° 30′ from the sun. Its declination at this time is —22° so that it will not be a conspicuous evening object for observers in the northern hemisphere.

Venus. Venus is a morning star reaching greatest western elongation on September 5, 13^h. On that date it will be situated 40° 57′ from the sun and will be a brilliant morning star. Information concerning the distance of the planet from the earth, angular diameter, etc., is tabulated on page 28 of the January, 1940, issue of POPULAR ASTRONOMY. An interesting conjunction of Venus with Neptune will occur on October 29, 21^h, when Neptune will be situated 11′ south of Venus.

Mars. Mars reaches conjunction with the sun on August 30. Thereafter for the duration of the year, the planet will be situated in the morning sky. It should be visible as a morning star by October 1. During October the planet is moving rapidly eastward in apparent motion through the constellation of Virgo. The stellar magnitude of the planet will be about +2. On September 28, 23^h, Mars will be in conjunction with Neptune and 13′ to the south of the latter planet.

Jupiter. Jupiter is nearing opposition (opposition November 3) and is to be found in the constellation Aries. It is well placed for observation during the months of September and October. The stellar magnitude is about —2.3. The apparent path of Jupiter is paralleling that of Saturn quite closely so that the two planets will constitute an interesting spectacle. A conjunction of Jupiter and Saturn will occur on October 11, 23^h, when Jupiter will be situated 1° 17′ to the north of Saturn.

Saturn. Saturn will be found during the months of September and October not far from Jupiter, as explained above, in the constellation Aries. The planet

appears during this period as a star of stellar magnitude 0. Through the telescope the southern side of the ring system is visible. Both Jupiter and Saturn should be excellent objects for telescopic study during the remainder of this year. An occultation of Saturn will occur September 20 invisible in the United States.

Uranus. On September 1, Uranus is a morning object, just having passed western quadrature, and situated at a point 47′ west of, and 29′ south of, the 5.5 magnitude star, 13 Tauri. On September 1, the planet ceases to advance and begins its retrograde motion. Apparent positions for the planet for September 1, October 1, and November 1, respectively, are listed below.

	α h m	δ ° ′
September 1	3 35.6	+19 1.6
October 1	3 34.1	18 56.4
November 1	3 29.9	18 41.9

Neptune. The planet Neptune will reach conjunction with the sun on September 18.

Asteroid Notes

By HUGH S. RICE

The subjoined lists show a number of the brightest asteroids, arranged in order of magnitude. Beside those given, there are a few others having magnitudes between 9.7 and 10.0. Also we give a number of the faintest ones, among those whose orbital elements are known. The magnitudes are mean magnitudes of opposition time. The list of brightest ones discloses the fact that 3 of the asteroids which are not among the so-called Big Four are brighter than one of these—Juno. The Big Four are commonly spoken of as the largest and brightest of the minor planets.

THE BRIGHTEST ASTEROIDS

	Planet	Magnitude		Planet	Magnitude
4	Vesta	6.5	40	Harmonia	9.2
1	Ceres	7.4	11	Parthenope	9.3
2	Pallas	8.0	18	Melpomene	9.3
7	Iris	8.4	192	Nausikaa	9.3
6	Hebe	8.5	10	Hygiea	9.5
15	Eunomia	8.6	39	Laetitia	9.5
3	Juno	8.7	16	Psyche	9.6
9	Metis	8.9	511	Davida	9.6
8	Flora	8.9	12	Victoria	9.7
29	Amphitrite	9.0	13	Egeria	9.7
20	Massalia	9.2	14	Irene	9.7

THE FAINTEST ASTEROIDS

	Planet	Magnitude		Planet	Magnitude
1221	Amor	18	452	Hamiltonia	16.7
1009	Sirene	17.7	1178	Irmela	16.6
719	Albert	17.6	1125	China	16.5
1134	Kepler	17.3	1448	1938 DF	16.5
887	Alinda	17.1	1460	1937 WC	16.3
944	Hidalgo	17.1	1405	1936 RE	16.2
878	Mildred	16.9	1473	1938 UT	16.2
1198	Atlantis	16.8	1179	Mally	16.1
1373	1935 QN	16.7	1205	Elbella	16.1

Disappointing though it be, none of the Big Four of the asteroids is suitable for observation during the last half of the summer, although later in the season some of them begin to come into favorable position. Therefore we are offering ephemerides and notes upon 6 of the brightest and presumably next best planets to observe at this time. In the third column of the next table, the reduction data are given, to reduce the ephemerides from the equinoxes of 1950 to that of 1940; and, as usual, in the column of logarithms, r is the distance of the planet from the sun in astronomical units, and Δ is the distance of the planet from the earth.

The data and ephemerides were made up from material computed by the minor-planet headquarters—the Coppernicus Institut, at Berlin-Dahlem.

Planet	Stellar magnitude	Reduction for α and δ		Date of opposition	Log of r	Log of Δ	Remarks
		m	′				
88 Thisbe	10.0	—0.5	—3	Sept. 4	0.377	0.140	(1)
63 Ausonia	9.7	—0.5	—3	Sept. 16	0.365	0.119	(2)
10 Hygiea	0.8	—0.5	—3	Sept. 19	0.520	0.365	(3)
393 Lampetia	9.6	—0.5	—3	Sept. 26	0.333	0.068	(4)
128 Nemesis	9.8	—0.5	—3	Oct. 5	0.381	0.149	(5)
19 Fortuna	8.8	—0.5	—3	Oct. 9	0.316	0.030	(6)

REMARKS

(1) West of the circlet of Pisces; on the evening of Aug. 30, 1° S. of β Piscium.

(2) Close to the circlet of Pisces; on the evening of Sept. 13, 1½° S. of λ Piscium. On Oct. 13, 5:00 A.M., E.S.T., conjunction of the moon and 63, with moon 1¾° south.

(3) Goes inside the circlet of Pisces; on Sept. 25, less than 1° N. of 19 Piscium.

(4) At the Pisces-Pegasus border; on the evening of Oct. 2, just S. of γ Pegasi.

(5) In western Cetus; on the evening of Sept. 15, 1° west of η Ceti.

(6) In Pisces; on the evening of Sept. 24, about 1° N. of ζ Piscium. On Oct. 15, close conjunction of the moon and 19, but invisible in U.S.

EPHEMERIDES OF ASTEROIDS. FOR 0^h U.T. EQUINOX 1950

88 THISBE			63 AUSONIA			10 HYGIEA		
	α	δ		α	δ		α	δ
	h m	° ′		h m	° ′		h m	° ′
Aug. 15	23 11.6	+ 3 7	Aug. 31	23 51.8	+ 1 13	Aug. 31	0 1.6	+ 5 36
23	23 6.2	+ 2 56	Sept. 8	23 44.3	+ 0 52	Sept. 8	23 56.4	+ 5 9
31	23 0.0	+ 2 33	16	23 36.4	+ 0 26	16	23 50.6	+ 4 37
Sept. 8	22 54.3	+ 2 2	24	23 28.5	— 0 1	24	23 44.7	+ 4 1
16	22 47.1	+ 1 25	Oct. 2	23 21.5	— 0 28	Oct. 2	23 39.1	+ 3 24
24	22 41.5	+ 0 48	10	23 15.7	— 0 49	10	23 34.1	+ 2 48

393 LAMPETIA			128 NEMESIS			19 FORTUNA		
	α	δ		α	δ		α	δ
	h m	° ′		h m	° ′		h m	° ′
Sept. 8	0 25.6	+19 12	Sept. 16	0 59.5	— 4 32	Sept. 16	1 15.0	+ 9 9
16	0 21.0	+17 49	24	0 53.8	— 5 10	24	1 10.2	+ 8 34
24	0 15.5	+16 8	Oct. 2	0 47.2	— 5 46	Oct. 2	1 4.2	+ 7 50
Oct. 2	0 10.0	+14 15	10	0 40.4	— 6 15	10	0 57.4	+ 6 59
10	0 5.3	+12 17	18	0 34.0	— 6 34	18	0 50.9	+ 6 8
18	0 1.8	+10 24	26	0 28.5	— 6 40	26	0 45.1	+ 5 22

Hayden Planetarium, American Museum of Natural History,
New York City, July 15, 1940.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1940	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
Sept. 14	137 B.Cap	6.2	0 25.0	—1.4	+2.1	48	1 43.7	—2.0	+0.5	273
15	186 B.Aqr	6.2	4 5.4	—1.1	+1.9	28	5 14.9	—2.3	—1.3	280
24	130 Tau	5.5	6 8.5	—0.9	+1.0	103	7 16.3	—1.0	+2.0	244
27	84 B.Cnc	6.4	6 36.9	0.0	+0.6	114	7 31.0	—0.2	+1.5	261
28	*h* Leo	5.3	7 30.1	—0.1	—0.2	139	8 13.8	0.0	+2.0	244
Oct. 7	305 B.Oph	6.4	1 0.6	—0.3	+0.9	29	1 41.1	—1.5	—3.1	317
7	BD—18°5079	6.5	22 33.7	—2.2	—0.6	112	23 46.3	—1.6	+0.4	231
12	*θ* Aqr	4.3	2 23.3	—1.8	+0.4	66	3 48.2	—1.4	0.0	242
12	252 B.Aqr	5.9	20 46.1	—0.2	+1.8	71	21 52.2	—0.6	+1.7	254
12	197 G.Aqr	6.4	22 0.6	—0.8	+2.0	69	23 14.6	—1.2	+1.6	250
14	60 B.Psc	6.0	7 3.4	—1.2	—3.0	119	7 48.1	—0.3	+1.8	198
21	111 Tau	5.1	1 55.3	..	..	150	2 17.1	..	..	194
21	115 Tau	5.3	3 29.1	..	..	1	3 39.8	..	..	342
22	287 B.Ori	6.2	2 52.9	..	..	160	3 9.2	..	..	193
22	292 B.Ori	6.5	3 47.1	+0.1	+2.6	48	4 37.1	—0.9	+0.2	305
23	λ Gem	3.6	5 5.7	—0.4	+1.6	84	6 12.2	—0.9	+0.9	280
24	30 B.Cnc	6.1	4 35.2	+0.3	+2.1	62	5 23.3	—0.5	+0.1	310
25	209 B.Cnc	6.5	6 34.9	—0.2	+2.6	59	7 21.4	—0.8	—0.7	324
28	31 B.Vir	6.4	8 49.5	—0.1	0.0	132	9 42.5	—0.5	+1.3	268
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Sept. 10	17 H^1Sgr	6.4	4 21.8	..	..	8	4 42.9	..	..	334
13	137 B.Cap	6.2	23 58.1	—0.9	+2.3	51	1 7.4	—1.4	+0.9	278
15	186 B.Aqr	6.2	3 41.9	..	..	3	4 23.9	..	..	308
19	*o* Psc	4.5	11 32.1	—1.0	+1.3	33	12 26.6	—0.7	—2.7	295
24	130 Tau	5.5	5 56.8	—0.2	+1.2	92	6 58.3	—0.4	+1.6	254
27	A^1 Cnc	5.7	11 21.8	..	..	173	11 47.2	..	..	212
Oct. 7	305 B.Oph	6.4	0 51.0	..	..	7	1 8.1	..	..	343
7	BD—18°5079	6.5	21 57.3	—1.8	0.0	117	23 10.6	—2.1	+1.2	236
11	72 B.Aqr	6.5	0 57.9	..	..	126	1 45.1	..	..	190
12	*θ* Aqr	4.3	1 47.2	—1.7	+1.7	49	3 14.3	—2.2	+0.2	260
12	170 B.Aqr	6.1	6 47.5	—1.1	—1.5	96	7 48.1	—0.2	+0.5	219
14	60 B.Psc	6.0	6 37.0	—2.1	—2.0	109	7 35.3	—0.6	+1.9	201
22	292 B.Ori	6.5	3 48.7	+0.7	+2.8	34	4 23.6	—0.5	—0.4	318
23	λ Gem	3.6	5 0.2	+0.2	+1.6	76	5 57.3	—0.4	+0.8	286
25	209 B.Cnc	6.5	6 31.1	+0.4	+2.3	56	7 11.6	—0.4	—0.6	323
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Sept. 10	*y* Sgt	5.4	4 41.6	—1.9	—0.5	83	6 2.4	—1.4	—0.7	258
19	*o* Psc	4.5	10 45.0	—1.5	+2.7	28	11 55.2	—2.4	—2.0	286
20	31 Ari	5.7	13 34.4	—1.5	+0.7	51	14 44.1	—0.9	—2.0	283
23	318 B.Tau	5.7	7 14.0	—1.1	—1.3	143	7 41.0	+0.8	+4.2	195
Oct. 6	29 Oph	6.4	2 5.8	—1.9	—1.7	122	3 10.1	—1.0	0.0	237
11	72 B.Aqr	6.5	0 5.9	—0.9	0.0	126	0 54.3	—1.3	+3.2	205
12	*θ* Aqr	4.3	0 58.1	—1.0	+2.6	40	2 5.9	—1.7	+0.6	283
12	*ρ* Aqr	5.4	3 19.2	..	..	126	4 2.3	..	..	183
12	170 B.Aqr	6.1	6 1.4	—2.0	+0.2	71	7 26.7	—1.4	+0.4	234
14	60 B.Psc	6.0	5 25.4	—2.4	+1.0	76	6 54.7	—1.8	+1.6	226
21	130 Tau	5.5	14 52.3	—0.3	—4.6	155	15 31.8	—2.0	+1.8	218

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated.

The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The card catalogue of fireballs which we have was examined for the year 1938 to see if any of the fireballs had been observed from two or more ships at sea. I was able to find five cases which seem quite certain, though in the one of them which could be fully solved the time was poorly recorded by one or both observers. I regret to say that only in two other cases could one point on the paths be determined, the other two cases cannot be solved. Eight of the records come from the Hydrographic Office, U.S.N., and two from the Marine Department of the U.S. Weather Bureau. The eight may be found in the Hydrographic Bulletins. All the ships counted G.M.T. from midnight; the A.M.S. counts it (old astronomical style) from following midday, hence the double date is given. For the two cases which permit no solution, it scarcely seems necessary to give the full data, so only part will be quoted.

(1) 1938 January 19/20, *Am. S.S. Forbes Hauptman,* λ 99° 10′ W, ϕ +16° 13′, 0333 G.M.T., . . . green, 3 × Venus, visible 20 seconds (does this mean duration of flight?). *Br. M.S. Cape York,* λ 104° 10′ W, ϕ +18° 34′, 0344 G.M.T. . . . brilliant . . . green tail . . . red before disappearing. Note: Neither ship gave *all* the coördinates of the path; those given were partly contradictory.

(3) 1938 July 26/27, *Am. S.S. E. R. Kemp,* λ 87° 07′ W, ϕ +26° 14′, 0925 G.M.T., . . . white, 2 × Venus, exploded . . . *Am. S.S. Albert E. Watts,* λ 88° 35′ W, ϕ +26° 43′, 0924 G.M.T., . . . very bright, visible 4 seconds, burst. Note: the coördinates of path are all given yet the azimuth lines *do not intersect.* This is probably due to erroneous position(s) of the ship(s). As an excellent solution was expected in this case, it is most regrettable.

The other full observations, with my solutions follow:

(2) 1938 June 4/5. "*Am. S.S. Tulsa,* Observer R. Hamann, 0405 G.M.T., . . . a very brilliant blue whitish meteor . . . one third size of sun and showed a faint tail. It produced a very strong flash about four times brighter than ordinary lightning bolt, lasted about 3 seconds between Altair and Jupiter, altitude about 39°, true bearing 255°. Position of vessel λ 27° 46′ W, ϕ +39° 42′." "*Br. Tanker Tynefield,* Observer L. C. Radford, 0406 G.M.T., λ 26° 46′ W, ϕ +38° 05′. Exceptionally bright meteorite, bluish white in color in constellation Ursa Major, starting at about altitude 36°, long red tail, visible about 6 seconds. Illuminated ship with brilliancy of a Very light. Moved in a NE'ly direction and disappeared at an altitude of about 8°."

The beginning point cannot be determined due to ambiguity but I find the end

point over λ 28° 16′ W, φ +39° 36′, height 36.5 ± 0.8 km. Other data as to the path cannot be determined, even roughly.

(4) 1938 Sept. 22/23. "Second Officer E. Denham . . . *Br. S.S. Iroquois* . . reports that at 0542 G.M.T., in φ +41° 08′, λ 55° 40′ W, . . . a greenish-white meteor, having twice the brilliance of Sirius, was observed which appeared near Sirius at an altitude of 18° 27′, bearing 116°, traveled for 3½ seconds in a slightly curved path to an altitude of 10°, bearing 136°, where it burst into small pieces. The pieces remained visible for 1½ seconds but disappeared before reaching the horizon." (Ship B.)

"Second Officer G. Henche, . . . *German S.S. Kelkheim*, . . . reports that at 0600 G.M.T., φ +39° 45′, λ 54° 55′ W, . . . a large yellow and red meteor was observed which appeared near Castor and Pollux at an altitude of about 25°, bearing 85°, traveled nearly parallel with the horizon and disappeared near Sirius at an altitude of about 18°, bearing 130°. The body left an enormous trail that was remarkably bright." (Ship A.)

A graphical solution, made in the usual way, was undertaken. This was quite satisfactory for the position of the projected beginning point, but it so happens that the azimuths of the end point from the ships differ by only 6° and hence converge too slowly. I therefore took an average position between the two lines and by a few trials found where along this line altitudes from A and B were best satisfied. In practice this amounted to decreasing the azimuth from A and increasing that from B by 3°, leaving the altitudes unaltered. Such small errors in azimuth indeed might be expected in practically all observations of fireballs. Also the G.M.T. differed by 18 minutes, showing that one or both were careless in their timing, but as 0600 looks less likely than 0542, twice the weight was given to the latter and 0548 assumed as true time. This approximation makes no difference whatever in anything except the α and δ of the radiant, through the sidereal time, and not very much even there. We find:

G.M.T. 1938 September 22/23	$05^h\,48^m$
Sidereal time at end point	49°
Began over	λ 52° 59′ W, φ +40° 06′ at 85 ± 06 km
Ended over	λ 53° 13′ W, φ +39° 01′ at 62 ± 01 km
Length of path	124 km
Projected length of path	121 km
Geocentric velocity	35 km/sec
Radiant (uncorrected)	h 10°.5; A 189°
Zenith correction (parabolic)	—2°.9
Radiant (corrected)	h 7°.6, A 189°; α 211°, δ +58°

No fireballs from a radiant near this position and for this part of September are found in Hoffmeister's Catalogue.

(5) 1938 Nov. 24/25. "Second Officer W. N. Young . . . British motor vessel *Oilpioneer*, . . . in φ +42° 44′, λ 15° 20′ E . . . at 0242 G.M.T. . . . brilliant blue meteor . . . traversed the sky in 2 seconds. It appeared bearing 185° at an altitude of 15° and disappeared bearing 350° at an altitude of 23°. The maximum altitude reached was 80°. The meteor left a trail which as a whole drifted in a southeasterly direction, except for the beginning, which formed an irregular zigzag line reaching to altitude 33°. It broadened out and finally disappeared at 0307 G.M.T."

"Second Officer T. Driscoll . . . *Am. S.S. Excello* . . . at 0245 G.M.T. . . . in φ +41° 26′, λ 11° 42′ E, a meteor of unusual brilliancy was observed. The body appeared at an altitude of about 12° under Regulus, and disappeared at an altitude

of 3°, under Polaris, leaving a trail, about as wide as the moon's diameter, that remained visible 8 minutes."

The beginning point of this was over λ 14° 58′ E, ϕ +39° 50′ at a height of 84 ± 09 km. The end point cannot be determined as the data are wholly contradictory, nor can anything else about this most important fireball be calculated. This is specially unfortunate as it left a long-enduring train whose drift I should particularly like to determine. As this object must have been visible from most of Italy, I searched in several publications but found no reference to it. Under war conditions as they are, it is probably hopeless to write for possible data that may exist in Europe. In future, perhaps more data will permit a good solution for this fireball.

The obvious points to be noted are the lack of key data, or carelessly recorded data prevented solutions in many cases. I suspect that some observers do not realize the necessity of getting the position of the ship with accuracy, a thing which in some cases might take considerable trouble. It is far more unfortunate to note that it is practically certain that every one of these objects was seen from other ships, the watch officers of which either did not record anything or, if they did, the captains did not see to the records reaching available publications. Nevertheless the aid meteoric astronomy does receive from these reports from ships has been very great and its value will be multiplied with time. We are most grateful to those officers, as well as all others, who do take the time and trouble to report.

1940 June 4, Flower Observatory, Upper Darby, Pennsylvania.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver
Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

Some Practical Aspects of Meteoritics

By H. H. NININGER

ABSTRACT

It is believed that a thoroughgoing program of research on meteorites and meteoric phenomena would yield knowledge of a practical nature. Some of the areas of life in which meteoritical research may prove of value are: weather forecasting, the lighting industry, mineral deposits, metallurgy, aëronautics, ballistics, and radio.

Scientific research is today endorsed as a matter of policy by leaders of industry. Huge sums of money are being constantly devoted to research of an exploratory character with no predetermined goal other than a better understanding of the forces and facts among which we live and move. It has been demonstrated many times that most important discoveries of a practical nature may be made while experimenting with facts and processes bearing no recognizable relationship to the objective obtained. Nevertheless, one is always justified in asking, What

are the possible advantages to be expected from an enterprise of such magnitude? It is possible to predict what discoveries may be made as a result of our proposed program of research, that will economically benefit mankind or that may physically advance the race. In certain areas of life, however, we may feel morally certain that our discoveries will have a practical bearing upon the social and economic life of man.

1. The problem of developing "long-distance" weather forecasting must depend, almost certainly, upon: (*a*) a better understanding of conditions in the upper atmosphere and (*b*) a more thorough study of variations in solar radiation. In the first instance, an adequate study of meteors is certain to produce important knowledge that can be gained by no other method, for the reason that as yet no sounding apparatus is able to reach the levels at which meteors are produced. In the second instance, a study of light phenomena, coupled with careful observations on the meteorites that survive, will furnish a key to many of the secrets of the upper air. Regarding solar radiation, certainly one of the factors essential to its proper understanding is the blanketing effect of dust in the atmosphere. The seasonal measurement of the fall of meteoritic dust will here furnish valuable information. Fortunately, we have lately learned how to collect and to study meteoritic dust.

2. The present vacuum-tube lighting industry is based upon a principle that is very closely allied to the phenomena of meteors in the upper atmosphere and would no doubt have been utilized much earlier had the study of meteors been seriously undertaken years ago. Further advances along this line and applications of this principle may be expected to result from a better understanding of meteoric phenomena.

3. A widespread and intensive study of meteorite craters will almost certainly throw new light upon the geological problems of mineralization in the Earth's crust. It is not improbable that nickel deposits may be found to be related to large meteoritic impacts, with the result that an aërial search for ancient impact craters may serve as a guide to fruitful prospecting.

4. It is asserted that the idea of using nickel-steel for armor plate came from a study of meteoritic iron. It is altogether probable that an exhaustive study of the various types of metallic meteorites may give rise to other advances in the use of alloy steels. Twenty-six varieties of nickel-iron meteorites have been described and yet not more than two or three of these varieties have been given what one might term even a near approach to exhaustive metallurgical study. The scarcity of material, which has been a barrier to such studies, will be removed by our large-scale search for meteorites.

5. Such a wide range in the degree of resistance to rust has been discovered in meteorites, that a careful consideration of these variations, together with the chemical composition of the materials, may throw new light upon the problem of stainless alloys.

6. An exhaustive study of the diamonds in meteorites may point the way to the production of artificial diamonds.

7. Certain minerals are found in meteorites that have not been found terrestrially. They are schreibersite, daubréelite, oldhamite, moissanite, maskelynite, weinbergerite, and merrillite. Because of their rarity, none of these has been exhaustively studied. Our large-scale collecting will render such studies feasible.

8. Thorough investigation of the explosive disintegration that marks the finish of the luminous flights of meteorites, coupled with a detailed study of the

heat effects registered in the fragments collected from these falls, and consideration of the forms that characterize surviving fragments, should throw new light upon the problem of air-resistance to high velocities. Here is an opportunity for aëronautical engineering to gain new light on problems connected with stratospheric transportation. Problems that face stratospheric flying are difficult to solve, chiefly for the reason that they lie beyond the reach of experimentation. Meteorites are constantly meeting with those conditions as they land upon our planet. By a careful study of meteorites, and the light phenomena that herald their arrival, a better understanding may be had of the difficulties that flying craft may some time have to meet.

9. The science of ballistics will need more and more to study the forms and markings of meteorites as the velocities attempted by ballistic engineers approach those of invaders from space.

10. No one can say that there is no relation between invading meteorites and cosmic rays.

11. Now that we have learned how to go about the study and measurement of meteoritic dust, one wonders whether there may be discovered some relationship between its constant sifting down and the growth of vegetation, as well as the healthy development of animal life.

12. Thousands of observations seem to point conclusively to the existence of *ethaërial sound* in connection with the flights of great meteors (see *C.S.R.M.*, **2**, No. 2, 79-81; *P. A.*, **47**, 97-9, 1939). This phenomenon appears to be a form of ether waves that, upon reaching suitable rectifiers among terrestrial objects, are transformed into ordinary sound waves. A plan has been worked out for demonstrating the phenomenon experimentally: it should have practical applications.

Dr. A. L. Coulson's New Catalog of Meteorites (Review)

"A Catalogue of Meteorites: with Special Reference to Indian Falls and Finds and to Specimens in the Indian Museum, Calcutta, as on August 1st, 1939," by A. L. Coulson, D.Sc., D.I.C., F.G.S., F.N.I., Superintending Geologist, Geological Survey of India; published by order of the Government of India as *Mem. Geol. Surv. India*, **75**, 346 pp., 6 pls., 1940; Calcutta: sold at the Central Book Depot, 8 Hastings St., and at the Office of the Geological Survey of India, 27 Chowringhee Rd.; Delhi: sold at the Office of the Manager of Publications; price, Rs. 4-8 or 7*s.*: Of the highest interest and value to all meteoriticists is this monumental new catalog by our fellow, Dr. Coulson, of which a copy has just been received. Lack of space forbids little more than an enumeration of the contents of this extensive work, from which, however, its scope may be fairly judged: Ch. 1, Introduction, p. 1; Ch. 2, Alphabetical List of Symbols Used in Chs. 3 to 8, p. 16; Ch. 3, Classified List of Specimens in the Indian Museum, p. 19; Ch. 4, General Catalogue, with Special Reference to Indian Falls and Finds and all Specimens of Meteorites in the Indian Museum, p. 30; Ch. 5, Classified List of Meteorites, with Dates of Fall or Find, p. 232; Ch. 6, Geographical Distribution of Meteorites, with their Classification, p. 280; Ch. 7, Dates of Fall of Meteorites, with their Classification, p. 304; Ch. 8, Dates of Find of Meteorites, with their Classification, p. 322; Ch. 9, Bibliography, p. 342; List of Plates, p. 346.

The only serious criticism that can be made of the catalog is that it does not give, generally, the total weight of material and the number of masses known for each fall; and it would be even more serviceable if it included a reference to at

least the original announcement or description of every fall. However, notwithstanding these defects, it contains a wealth of information for statistical and other studies and will be found indispensable for most purposes.

The reviewer had the pleasure of meeting Dr. Coulson in the summer of 1938, at the British Museum (Natural History), South Kensington, London, England, where he (Dr. Coulson) was engaged in the compilation of his catalog. F.C.L.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Cluster Type Variables in Messier 3: A recent study by Dr. Martin Schwarzschild, with the 61-inch reflector at Oak Ridge, of the cluster-type variable in Messier 3 has brought to light some interesting facts which bear on the problem of Cepheids, and perhaps indirectly on other types of intrinsic variables. The problem involved the determination, by photographic methods, of the blue and red magnitudes for variables in this well-known cluster, which has been for so many years an object of intensive study at Harvard and elsewhere.

Schwarzschild's purpose was to obtain information concerning the period-density relation of cluster-type variables, and the relative positions of variables and non-variables in the color-magnitude diagrams of globular clusters. The use of Greenstein's light curves of cluster-type Cepheids in Messier 3, suitably corrected, gave the desired mean magnitudes necssary for Schwarzschild's study.

Bailey in his early work on these variables was able to divide them into three classes, "a," "b," and "c": class "a," period and light curve uniform, with increase of light very rapid, and decrease rapid but less so than the increase; class "b," period and light curve probably uniform, but with increase only moderately rapid and decrease relatively slow, with a frequent tendency toward a still-stand and periods averaging longer than "a"; class "c," period and light curve perhaps uniform but with light changing continuously and with moderate rapidity, resembling a sine curve in contrast to classes "a" and "b." Class "c" periods are usually shorter than those for "a" and "b." Subsequent study has shown that many cluster-type variables are subject to period changes similar to those found for RR Lyrae.

A plot of the color-index (C.I.) values of the stars studied by Schwarzschild indicates that the C.I. does not increase with the period nearly so much as would be expected theoretically. This effect was previously noted by Shapley, but if the variables are divided into two groups, one containing c-type variables having periods less than $0^d.4$, and another containing a- and b-types, with periods greater than $0^d.4$, there is found to be a measurable difference in C.I. If this difference is real, Schwarzschild concludes that those variables with the longer periods have either a slightly larger specific-heat ratio, or a slightly stronger mass concentration. Hence, the a- and b-type variables appear to fulfill the period-density relation as well as can be expected, whereas the c-type variables show a decided deviation from it, with periods too short for the densities. Perhaps the c-type variables are pulsating in a different mode from the a- and b-types, the former pulsating in the first overtone and the latter in the fundamental tone. To confirm these sug-

gestions Schwarzschild recommends that this sort of investigation be expanded to cover the Omega Centauri cluster. It is also concluded that non-variables in the Messier 3 cluster do not abound in the interval of color and absolute magnitude occupied by the variables themselves, which indicates, as Dr. Schwarzschild states, that stars which can pulsate do pulsate.

Gamma Cassiopeiae: A recently published set of observations of γ Cassiopeiae, made by Joseph Ashbrook for the interval October, 1936, to December, 1939, provides much material additional to that already obtained by visual observers of the light variations of this peculiar variable star. All the observations submitted by the A.A.V.S.O., together with those by Ashbrook, have been combined into five-day means and are represented in the accompanying diagram.

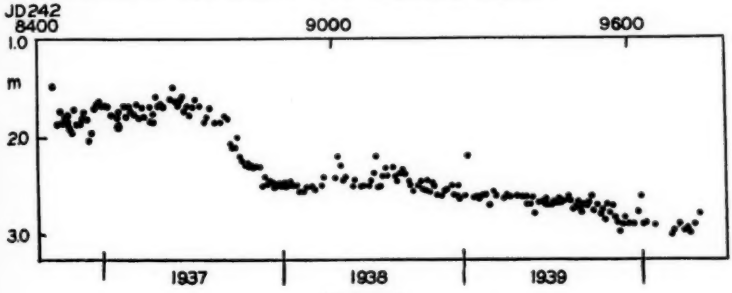


FIGURE 1
OBSERVATIONS OF GAMMA CASSIOPEIAE.

The total range in variation during the years here indicated is from $1^{M}.6$ to $2^{M}.9$, larger than ever before noted from the somewhat desultory observations available. The minor fluctuations shown by Ashbrook's observations alone are not so marked as those found by C. M. Huffer in his photoelectric measures, but they are larger than those indicated by the mean light curve obtained from all the visual observations. This difference is perhaps to be expected, because of the higher degree of accuracy attainable with the photoelectric photometer; and also because, in the means obtained from observations by various observers, small fluctuations are generally smoothed out.

Ashbrook comments that, although a new spectral cycle has recently begun, the brightness of the star has remained quiescent, apparently at minimum. Since January, 1940, the star appears to have continued this fairly constant state at magnitude 2.9, which may—or may not—mean that a change in brightness is now to be expected. A close watch on this variable during the next few months is recommended.

The A.A.V.S.O. Meeting in Toronto: The twenty-ninth annual spring meeting of the A.A.V.S.O. was held in Toronto and Richmond Hill, Ontario, on May 31 and June 1, 1940. The meeting can be considered as held jointly with the Toronto Center of the Royal Astronomical Society of Canada since four-fifths of those present were members of that organization. Thirty-odd A.A.V.S.O. memmers travelled from the States, mainly from New England, New York, Michigan, and Wisconsin.

The program of the Friday evening session was in the hands of the R.A.S.C., with the A.A.V.S.O. as guests, and was held at the University of Toronto in Tor-

onto. After greetings from Chairman S. C. Brown of the R.A.S.C., who also gave a brief résumé of the variable star field and its work, Professor John Satterly of the University of Toronto gave a very clear and thrilling demonstration of the uses and effects of liquid air, principally by means of laboratory experiments.

The A.A.V.S.O. council met late Friday evening and, among other things, elected eight candidates to active membership and added one life member to its rolls.

The sessions on Saturday were held at the David Dunlap Observatory at Richmond Hill under the auspices of the A.A.V.S.O. with Madame President Helen Sawyer Hogg in the chair. David B. Pickering, in the absence of Mr. Rosebrugh, acted as secretary *pro tem.* After the reading of reports of officers, tribute was paid to those members who had died since the previous meeting: A. L. Wallon of Syracuse, New York; Dean Potter of Leonia, New Jersey; and Professor H. C. Wilson of Northfield, Minnesota.

Reports of committees included those of the Chart Committee and Chart Curator, the Auroral Committee, and the Nova Search Committee, all of which evoked much more discussion than usual. The Nova Search Committee reported the assignment to members of special regions, widely distributed over the northern sky; and also that the South African observers had agreed to coöperate and look after the southern sky. Reports had already begun to come in to headquarters. The work of the Auroral Committee was explained by E. A. Halbach, Chairman, and later was more fully discussed by C. W. Gartlein of Cornell University, who was responsible for starting this highly important program of observation. The work is to be carried on both visually and photographically, and already much has been done in both fields.

The presentation of papers then followed, and, although few in number, they were of considerable interest and much discussed. Mrs. Margaret W. Mayall reported on her discovery of the longest long-period variable (see these notes for June, 1940). Mr. C. B. Ford of the Ladd Observatory discussed his new type of photometer, which employs polaroid as the means for equalizing the light of the two stars involved. Although earlier samples of polaroid proved unsatisfactory, the new improved material gives promise of success. L. E. Armfield presented a carefully prepared paper on auroral statistics and their relation to terrestrial and solar activities, and on the relation of such phenomena to telephonic, telegraphic, and radio disturbances; he noted the possibility in the near future of effecting practical methods of predicting such disturbances.

After luncheon at the Community Church in Richmond Hill, under the expert direction of the ladies of the church, a group photograph was taken before the resumption of the short afternoon session. Dr. R. K. Young, Director of the Observatory, welcomed both associations and described the general equipment and work of the observatory.

The late afternoon was spent at the Don Alda Farms where those who were attending the meetings were graciously received and entertained at tea by Mrs. David Dunlap. A garden party had been planned, but inclement weather precluded this much anticipated event.

On Saturday evening all the members of both organizations gathered at the Great Hall of Hart House in Toronto for the banquet. Madame President Hogg acted as toastmistress. After toasts had been offered to King George and President Roosevelt, Mr. C. W. Elmer proposed a toast to the R.A.S.C., responded to by Mr. Brown. Dr. Frank S. Hogg toasted the A.A.V.S.O., and Mr. Pickering

responded with the reading, in his inimitable style, of a poem dedicated to the Sage of Leonia. Dr. Shapley offered a toast to the University of Toronto, to which the Honorable Reverend H. J. Cody, President of the University, responded.

Recorder Campbell, in a dreamy sort of fashion, spoke at some length on the early days of the A.A.V.S.O., in which he referred to the original organizers and observers, in particular to the pioneer work of Olcott, Bouton, Chandra, Pickering, McAteer, Yalden, Miss Young, and others. The Recorder mentioned the achievements of the association during the nearly thirty years of its existence, and referred to the present and future value of variable star observing towards the possible solution of how and why stars vary.

Dr. C. A. Chant, Director Emeritus of the David Dunlap Observatory, traced the fifty-year history of the R.A.S.C. from its beginning as a small, local astronomical unit to its present dominional expansion, with centers in many cities throughout Canada. The aims of the Society's "Journal" and "Handbook" were carefully outlined.

Dr. Shapley took up the task of prognosticating what astronomers would be doing in 1950 and the developments in the next ten years which would make their work possible. The further adaptation of gadgets to present day astronomical instruments and processes, including new photographic developers and the sensitization of plates and improved techniques for using them, were stressed. The extended use of ultra-Schmidt-type telescopes was also mentioned, with their possibilities for delving into space. New theories on the origin of the solar system, based principally on further investigation of the smaller bodies in our system—such as the asteroids, meteors, and comets—and a better knowledge of the external galaxies throughout metagalactic space as the result of more extensive surveys with Schmidt telescopes, were touched upon. Probably the most valuable field for research will be the study of the solar corona and prominences, through the further development and use of the coronagraph and similar equipment, and their correlations with terrestrial phenomena. Here even the meteorologist will find a modified form of the coronagraph useful in the study of the upper air.

Both groups adjourned, following the rendition of the national airs. The A.A.V.S.O. will next gather at the Harvard Observatory in October for the annual meeting.

Observers and Observations, May-June, 1940:

Name	May Var.	May Obs.	June Var.	June Obs.	Name	May Var.	May Obs.	June Var.	June Obs.
Ahnert	39	361	..	..	Ensor	48	88	45	64
Albrecht	32	63	..	..	Escalante	4	4	..	..
Baldwin	73	130	82	176	Ferguson	7	8	8	12
Ball, A. R.	22	25	..	..	Fernald	75	101	47	70
Ball, J. M.	14	14	..	..	Ford	16	16	..	..
Bappu	110	142	..	..	Forrester	2	4	8	12
Blunck	24	26	24	28	Franklin	13	18	..	..
Bouton	42	59	37	37	Gregory	71	95	27	36
Britzelmayer	4	5	..	..	Griffin	53	63	29	35
Brocchi	..	..	8	11	Guthrie	4	4	..	..
Buckstaff	15	81	70	104	Harris	59	64	48	52
Callum	18	18	..	..	Hartmann	105	184	108	135
Carpenter	..	..	21	22	Holt	120	388	95	104
Chilton	4	4	..	..	Houghton	68	134	82	177
Cilley	25	51	37	102	Howarth	18	31	11	13
Cousins	43	104	41	100	Huffer	..	..	8	8
Dafter	7	27	7	30	Irland	5	5	..	..
Diedrich	18	26	..	..	Jones	57	198	33	33

Name	May Var.	May Obs.	June Var.	June Obs.	Name	May Var.	May Obs.	June Var.	June Obs.
Kanda	..	..	2	10	deRoy	..	..	13	31
Kearons	..	..	37	51	Russell	12	15	15	18
Kelly	16	21	13	18	Ryder	5	5	..	..
deKock	62	293	66	297	deSantis	..	..	7	8
Kozawa	..	..	16	63	Saxon	18	19	..	..
Loreta	198	942	..	..	Schoenke	16	27	..	..
Lovinus	7	7	..	..	Shafer	2	3	6	14
Mages	11	11	..	..	Shultz	..	..	10	10
Mason	2	3	..	..	Sill	21	21	34	38
Maupomé	22	22	..	..	Smart	5	5	..	..
McDevitt	6	6	..	..	Smith F. P.	7	14	13	13
McKeon	..	..	2	2	Stangor	..	..	8	8
McPherson	19	19	12	20	Topham	115	115	20	20
Moore	12	12	..	..	Townsend	8	8	9	13
Nadeau	..	..	1	1	Walton	15	21	..	..
Nance	13	13	..	..	Webb	12	13	9	10
Palo	28	31	8	9	Weber	9	9	11	11
Parker	14	15	33	34	Whittier	..	..	5	5
Peltier	24	83	16	60	Williams	..	..	12	55
Prinslow	3	3	..	..	Yamada	8	14	..	..
Purdy	..	..	12	14	Yamasaki	..	..	12	12
Rense	14	14	..	..					
Rosebrugh	13	53	8	45	80 (Totals)		4387		2251

July 3, 1940.

Comet Notes

By G. VAN BIESBROECK

The tragic world events evidently distract the attention of observers from celestial phenomena. No new comets have been reported for several months nor have any known ones been observed. The search for PERIODIC COMET 1929 (NEUJMIN) should be continued in the region of the ephemeris given on p. 325. In spite of the uncertainty of the position, the chances for recovering it are best in June and July.

Not far from the region presumably occupied by this comet, another expected comet may soon be found. It is PERIODIC COMET 1933*f* (WHIPPLE) for which H. Q. Rasmusen has computed a period of 7.5 years. Perihelion is predicted for the date January 13, 1941, so that the object is still far away from the sun. But by next October it should be well accessible to ordinary instruments. The following ephemeris was given by the Danish computer, H. Q. Rasmusen (*Astron. Nachrichten* No. 6056).

EPHEMERIS OF COMET 1933*f* (WHIPPLE)

1940 0^h U.T.	(1940.0) α h m	δ ° ′	Distance from— sun	earth
July 6	22 56.6	+2 51	2.759	2.145
14	22 58.8	3 2		
22	22 59.8	3 8	2.718	1.941
30	22 59.4	3 3		
Aug. 7	22 57.8	2 45	2.680	1.775
15	22 55.0	2 14		
23	22 51.3	1 30	2.645	1.662
31	22 46.9	+0 36		
Sept. 8	22 42.3	−0 26	2.612	1.611

Williams Bay, Wisconsin, June 11, 1940.

Notes from Amateurs

ASTRONOMICAL RELATIONSHIPS II
(Fundamental Constants Involving Light)

It has been shown in a previous article* that a simple numerical relationship exists between the earth and the heavenly bodies that appear to revolve regularly around it, as expressed by the equation

$$y = \frac{\log P}{U} + 7 \qquad (1)$$

where P is the sidereal period of eastward revolution in years, U is the number of sidereal days in a year divided by 1000, or 0.3662422, and y is the space number. The numerical values of y are as follows: earth 0, moon 4, sun 7, Mars 8, asteroids 9, Jupiter 10, Saturn 11, Uranus 12, Neptune 13, Pluto 13.5, and the stars 19.

The space number y can also be calculated from the period of revolution by the following equations:

$$P = (1000\,U)^{[(y/7)-1]} = 366.2422^{[(y/7)-1]} \qquad (2)$$

from which

$$y = 7\left\{\frac{\log P}{\log 366.2422} + 1\right\} \qquad (3)$$

If the sidereal period of revolution of each body is measured in units of sidereal days, and designated as P_d, the equations may be further simplified, as follows:

$$P_d = (1000\,U)^{y/7} = 366.2422^{y/7} \qquad (4)$$

and

$$y = \frac{7 \log P_d}{\log 366.2422} \qquad (5)$$

It is the purpose of the present article to show that some of the fundamental observational constants associated with light are also directly related to the number of days in a year.

Observations of the stars show that in addition to their uniform eastward precession of 50″ a year with respect to the equinoxes, amounting to one revolution in about 26,000 years, they have a superimposed cyclic motion. They move alternately backward and forward, with a maximum displacement of 20″.47 on either side of their fictitious central positions, in the course of a year. A star has its maximum eastward displacement when in opposition to the sun, and its maximum westward, or retrograde, displacement at conjunction.

A star in opposition to the sun is displaced to the east by such an amount that the earth must rotate an additional 20″.47 to compensate for the displacement. This constant quantity is called the "aberration of light," and is equivalent to 1.365 seconds of time, or $1^s.365$. The aberration is explained as being the combined effect of the yearly revolution of the earth around the sun, and the velocity of light. It is one of those important constants of nature that can be obtained by direct observation.

*Fred C. Bond: "An Astronomical Relationship," POPULAR ASTRONOMY, Vol. XLVIII, No. 4, (April, 1940).

The maximum displacement, or twice the aberration, is $1/(10)^{9/3}$ of a complete circle. The numerical relationship in the customary units is

$$a = 1/2U = 1^{s}365 \qquad (6)$$

where a is the aberration of light in time seconds.

The maximum aberrational displacement in time seconds is $1/U$.

The first measurement of the velocity of light was obtained from observations of the eclipses of the four largest satellites of Jupiter by the shadow of the planet. The time of these eclipses was observed to run through a regular yearly cycle of retardation and acceleration, amounting to about 16½ minutes. When Jupiter was in opposition to the sun the eclipses regularly occurred 16½ minutes in advance of those at conjunction, six months earlier or later.

This change was found to be constant for other planets as well, and was considered to be the time required for light to cross the earth's orbit. Half of the observed change, or exactly $498^{s}6$, was considered to be the time required for light to travel from the sun to the earth, and was called the "constant of the light equation."

The earth is nearest to a superior planet when the planet is in opposition to the sun. When the bodies are in this position the time of eclipse advances $498^{s}6$ from its time at quadrature; this is equivalent to 2.0775 degrees of rotation of the earth. At conjunction it is reduced by an equal amount.

The relationship between the constant of the light equation and the aberration of light is very direct. The aberration of light multiplied by the number of solar days in a year equals the constant of the light equation, no matter what units of angular measurement are employed. For example, $1^{s}365$ multiplied by 365.2422 equals $498^{s}6$, and $20''.47$ multiplied by 365.2422 equals $7476''.5$, which is equivalent to $498^{s}6$.

The number of solar days in a year is equal to $1000\,U - 1$.

If the constant of the light equation, or half of the total yearly displacement, is measured in time seconds and designated as A, then the relationship in the customary units is

$$A = \frac{1000\,U - 1}{2\,U} = 498^{s}6 \text{ (or } 2^{\circ}0775) \qquad (7)$$

The reason for these simple relationships between the aberration of light, the constant of the light equation, and the number of times the earth rotates during one revolution of the sun, will not be discussed in detail in this paper. They are not mentioned in any work on astronomy that the author is familiar with, and the Copernican structure appears to supply no basis for them. Both of the light constants are assumed to be effects only of the *yearly* revolution of the earth around the sun, and the fact that they are also related to the number of days in a year argues strongly for the existence of a hitherto unknown extension of celestial harmony. Perhaps this is one of the correspondences that Kepler suspected in his *De Harmonice Mundi.*

FRED C. BOND.

1645 S. 80th Street, West Allis, Wisconsin.

The Eighth Year of the Rhode Island "Skyscrapers"

The annual election and business meeting of Skyscrapers, Inc., amateur astronomical society of Rhode Island, was held in Room 1, Wilson Hall, Brown University, Providence, R. I., on June 5, 1939. The following officers were elected: President, Archibald C. Matteson; Vice-Presidents, Roy K. Bilsborough and Mrs.

Frank Sherman; Secretary-Treasurer, Miss Mary H. Quirk. The society heard with deep regret of the sudden death of Mr. Matteson on June 24, 1939. His office was filled by Mr. Bilsborough, and Mr. William W. Estes was elected a vice-president.

The program of the eighth year was as follows:

July 12, 1939. Outdoor meeting at the home of Mr. and Mrs. Frank Sherman, Johnston, R. I.

August 24, 1939. Outdoor meeting at the Skyscrapers' own observatory, the Seagrave Memorial Observatory in North Scituate, R. I.

September 21, 1939. Outdoor meeting at Seagrave Observatory, North Scituate.

October 4, 1939. Dr. Charles H. Smiley, chairman of the Department of Astronomy at Brown University, spoke on "Observatories West of the Rockies." Miss Wilhelmina Null, a member of the Photographic Section of Skyscrapers, showed color photographs taken on her summer trip to Norway, Denmark, and Sweden, including a number of the midnight sun.

October 21, 1939. The Convention of New England Telescope Makers was held in Metcalf Auditorium, Brown University. Mr. Frederick W. Hoffman was chairman of a committee of Skyscrapers to help arrange for the event. Lectures and speakers were: "The Foucault Test of Mirrors and Lenses," Leland S. Barnes; "The Foucault Test Applied to the Joseph Brown Gregorian Reflector," Ernest R. Hager; "Hartmann's Method of Testing Telescopes," Alice H. Farnsworth; "Testing Schmidts and Schwarzschilds," Charles H. Smiley; "Some Remarks on Testing Telescopes," A. W. Everest; "Figuring Mirrors by Aluminizing," Alfred B. Focke.

November 8, 1939. Rev. W. M. Kearons of Fall River, Massachusetts, spoke on "Sun Spots," and showed his collection of solar photographs taken daily over a period of twenty years.

December 5, 1939. Wagn H. Hargbol of the Boston Amateur Telescope Makers gave a talk on "Tricks in Teaching Telescoptics."

January 3, 1940. Clinton B. Ford, a member of the staff of Ladd Observatory, Brown University, lectured on "The Causes of Stellar Variability."

February 5, 1940. Dr. Harlan T. Stetson, Research Associate at Massachusetts Institute of Technology, spoke on "The Sun and Our Atmosphere."

March 6, 1940. The planet Mars was the subject of discussion by three members of the society. Dr. Charles H. Smiley talked on "The Scientific Facts about Mars." Miss Wilhelmina Null discussed "Speculations on Habitation," and William Gardner spoke on "Planetary Detail," using a globe of the planet which he painted after studying pictures of the planet.

April 7, 1940. Three members of Skyscrapers accompanied Professor Smiley to Thomasville, Georgia, to photograph the annular eclipse of April 7, 1940. They were Mrs. Smiley, Frederick W. Hoffman, and Arthur A. Hoag. Observations were made at Ladd Observatory by Miss Grace Harris, and at Seagrave Observatory by Donald S. Reed. Both are members of Skyscrapers.

April 17, 1940. Dr. and Mrs. Smiley, Mr. Hoffman, Miss Harris, and Mr. Reed explained their work during the eclipse.

May 8, 1940. The eighth annual dinner of the society was held at Faunce House, Brown University. Following the dinner, more than 250 members and guests of Skyscrapers, Inc., heard Dr. Clyde Fisher, Director of the Hayden Planetarium, New York City, speak on "Messengers from Outer Space." Dr.

Fisher was the speaker at the first annual meeting in 1933.

Open Nights are held monthly throughout the year at Seagrave Observatory in North Scituate for members and guests to look through the 8-inch refractor.

Seven books were purchased for the library, and a case for the society's collection of astronomical slides was donated by Mr. George Euart and Mr. John Euart.

Telescope making, observations of meteor showers and variable stars, stellar photography, and computations of orbits have kept busy the members of the various sections of the society.

At present the Skyscrapers are working on plans for the Brown University-Skyscrapers, Inc., Eclipse Expedition to Pernambuco, Brazil, where Dr. Smiley expects to photograph the total solar eclipse of October 1, 1940. He will be accompanied by Mrs. Smiley and Arthur Hoag, both of whom assisted at the April 7, 1940, eclipse in Georgia.

MARY H. QUIRK, *Secretary-Treasurer.*

Pawtucket, Rhode Island, May 31, 1940.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

An Explanation of the Periodicity of Sunspots

The sun is a very slightly pulsating star whose variations in size are accompanied at the contracting phases by many sunspots and at the expanding phases by few sunspots. This pulsation covering a period of ten or eleven years, by changing the sun's interior pressure and upsetting the equilibrium of its forces, is responsible for the periodic cycles of sunspots.

Though it does not work by the same physical principles, this process can be easily compared to a sponge which, when squeezed at intervals, presses out drops of its inner moisture to the surface. The relation between the sun's variability and sunspots is explained in the following paragraph.

Though the sun is usually considered a stable star, certain facts and measurements show that it has a slight pulsation. In his book, "The Sun," Giorgio Abetti wrote: "Father Secchi and Father Rosa of the Collegio Romana studied the variations of the solar diameter by using the observations then available, the latter, in a detailed memoir, concluded that at epochs when the number of sunspots and prominences is at a minimum, the equatorial diameter is at its greatest. Discussing the observations made by Hilfiker with the meridian circle, R. Wolf obtained a result for the sunspots of 1870 (the largest maximum known) in agreement with what he calls the "Secchi-Rosa law."

"Systematic observations of the transit of the solar diameter which demonstrate its variability have also been carried out at the Campidoglio Observatory since 1877. . . . The length of the period is uncertain but seems to be approximately that of the sunspot cycle." Measurements of the sun's variations in size are very uncertain due to irradiation and atmospheric conditions on earth but they seem to show a variation of 0.2 or 0.3 second or about 150 miles.

It is known that the sun's surface is brighter per area at times of sunspot maxima. Instead of being caused by sunspots, this may be caused by the sun's contraction in size which would make its surface brighter. Since this shows that the sun may contract at times of sunspot maxima, the contraction may be the cause of sunspots.

The fact that sunspots occur in regular cycles shows them to be perhaps related to or caused by a rythmic pulsation of the sun, since variability is the most common and universal cycle known to occur in stars and any other regular stellar cycle is probably dependent on it.

The Mechanical Explanation of the Hypothesis

If the sun's interior were an inert liquid or gas, it would be impossible to force up masses of material from its interior by contracting in size because a material must have greater density than a substance beneath it in order to force that substance upward by gravity. The densest part of the sun is always at its center.

However, a gas when compressed, increases its outward pressure and heat enormously. While the sun's exterior is pressing down on its center, the compressed interior exerts a terrible outward pressure on account of its great heat and small volume until the two opposing forces of gravitational pressure and pressure of expanding gas are balanced.

If the sun were a stationary sized body, it would remain so but if it is a body that contracts, the decreasing volume and increasing weight of the exterior region would force in the interior until it was compressed and heated beyond the equilibrium of the balancing forces then the interior would react, exerting the greater pressure on the exterior region, expanding and shooting up masses of gas which would reach the surface and become sunspots.

In all theories, sunspots are considered to be masses of expanding cooling gas rising from the sun's interior and that is why the outbursts of sunspots would come at times of contracting pulsation. That is also how they would be related to the sun's variability. The main objection to this hypothesis is that such a small variation in the solar volume could not be responsible for the phenomena of sunspots. However, sunspots, though often large in surface, represent a very tiny per cent of the sun's volume, small enough to be logically caused by the slight change in solar volume.

Besides this, it is probable that the process described above is not responsible for the entire number of sunspots but is the cause of their origin, and, by upsetting the complex dynamics of the sun, other forces are set at work increasing the number of sunspots. So in summary the mechanical cause of the periodicity of sunspots is explained in the following stages:

(1) The sun is a slightly pulsating star.

(2) After the expanding phase of pulsation, the sun begins to contract again.

(3) As it contracts, it gets smaller and denser thereby increasing the pressure on its interior which is compressed.

(4) The interior is compressed and heated to the point where its outward pressure is superior to the weight of the exterior layers pressing down on it.

(5) Because of its superior outward pressure, the sun's interior expands, forcing masses of expanding gas to the surface to cool off, spread out, and turn into dark sunspots. This phenomenon may cause only a little sunspot activity but since the slightest change can upset the stability

of a gaseous star, it brings on other forces, currents, etc., that increase the sunspot activity to the full degree.

(6) Now the whole sun having reached its limit of contraction begins to expand again and the sunspots cease.

(7) After the sun has reached its greatest expansion, it begins to contract again. It repeats this process again and again also repeating the periodic outbursts of sunspots.

EXPLANATION OF THE CHANGING LATITUDE OF SUNSPOTS

At the beginning of each cycle, sunspots appear in the northern and southern solar latitudes at 30°, then their zones begin to draw in towards the equator while they reach their maximum (16°). After this, they dwindle away near the equator at a latitude of six degrees.

It is known that the solar and equatorial regions of the sun rotate at different speeds, therefore the southern and northern middle latitudes are regions of conflicting action where these currents interfere with each other.

Since it is easier for sunspots to rise up through a disturbed region and a broken surface than it is for them to well forth in regions of calm constant pressure, the sunspot zones at the beginning of the cycle would appear in these middle northern and southern latitudes.

Then, due to centrifugal force, the zones move outward and downward to the equator, and while the zones are moving downward the new spots keep appearing only in their vicinity.

Then the sunspots decline before reaching the equator and never appear on it because its rotation is harmonious and undisturbed. The spots mostly appear in disturbed regions instead of the calm regions of the equator and poles.

LESTER SUSSMAN.

1411 S. Sawyer Avenue, Chicago, Illinois, May 15, 1940.

General Notes

Dr. John C. Hammond, from 1917 to 1934 astronomer at the U. S. Naval Observatory, with which he had been connected since 1898, died on May 11 in his sixty-eighth year. (*Science,* May 17, 1940.) (See page 364.)

Dr. Edwin P. Hubble, of the Mount Wilson Observatory, has been awarded the 1940 Gold Medal of the Royal Astronomical Society "for his outstanding work on the distances, velocities, distribution, and nature of the extra-galactic nebulae."

Dr. W. E. Harper, Head Astronomer of the Dominion Astrophysical Observatory, Victoria, B. C., died on Tuesday, June 4, after a long illness. Dr. Harper was President of the Royal Astronomical Society of Canada in the years 1928 and 1929, and for several years has been an associate editor of this Journal. (*Journal of the Royal Astronomical Society of Canada,* May-June, 1940.)

The Rittenhouse Astronomical Society and their friends made a special tour of inspection of the United States Weather Bureau conducted by Mr. Henry E. Hathaway, former president of the Society and Meteorologist of the Weather

Bureau, on Friday evening, June 14, 1940. Mr. Hathaway, known to the radio public as "The Voice of the Weather," broadcasts daily except Sundays at 7:30 A.M. over Station WCAU.

The Sixty-Fourth Meeting of the American Astronomical Society

The sixty-fourth meeting of the American Astronomical Society will be held at Wellesley College, Wellesley, Massachusetts, September 11-14, 1940. The following tentative program has been arranged by the secretary.

WEDNESDAY, SEPTEMBER 11

Afternoon—Registration, establishment of residence, inspection of college campus and buildings.

4:00* P.M.—Tea at Observatory House on invitation of Professor and Mrs. Duncan.

8:00 P.M.—Council meeting at Green Hall; open house at Whitin Observatory.

THURSDAY, SEPTEMBER 12

9:00 A.M.—Opening session: address of welcome by President Mildred H. McAfee of Wellesley College; reply by President Robert G. Aitken of the Society; papers.

12:30 P.M.—Society photograph.

2:00 P.M.—Session for papers.

Evening Feature to be arranged.

FRIDAY, SEPTEMBER 13

8:30 A.M.—Council meeting, Green Hall.

9:00 A.M.—Annual business meeting, including election of officers; retiring address of President Aitken; session for papers.

2:00 P.M.—Session for papers.

5:00 P.M.—Carillon concert.†

7:00 P.M.—Society dinner.

SATURDAY, SEPTEMBER 14

Morning Excursion to Oak Ridge station of Harvard College Observatory (about 30 miles from Wellesley); inspection of astronomical equipment and possibly visits to certain nearby celebrated private museums.

12:30 P.M.—Picnic at Oak Ridge (compliments of Harvard Observatory).

*Eastern daylight-saving time. †Not yet arranged.

Eclipse Expedition to Brazil

An attempt to prove definitely that the zodiacal light of the sun can be photographed during a total eclipse will be made on October 1 by an expedition from Brown University headed by Professor Charles H. Smiley, chairman of the Department of Astronomy, which will journey to South America for the eclipse on that date. The expedition, sponsored also by the Skyscrapers, Providence amateur astronomical society, will set up its high-speed cameras near the village of Quixeramobim, Brazil, at the eastern shoulder of South America about 100 miles northwest of Pernambuco. At this point the total eclipse will occur at 10:00 A.M., and will last for nearly 5 minutes.

Accompanying Professor Smiley will be his wife and Arthur A. Hoag of Barrington, Rhode Island, a junior at the university. Dr. Alice Farnsworth, head of the Department of Astronomy at Mt. Holyoke College, may join the Brown

group in South America. They anticipate good weather for the eclipse, since it seldom rains or is even cloudy in Quixeramobim in October.

Two astronomical instruments recently devised, the coronagraph and the coronavisor, now permit astronomers to view the bright inner corona of the sun at any time, but an eclipse is still necessary to see the outer corona and the fainter zodiacal light, Professor Smiley pointed out.

The expedition plans to leave Providence about August 15. With the European war eliminating many steamer routes, they will probably have to take a boat for Rio de Janeiro, and then retrace their route via the coast of Brazil, either by land, air, or water, to Quixeramobim.

Book Reviews

Planets, Stars, and Atoms, by George Edwin Frost. (The Caxton Printers, Ltd., Caldwell, Idaho. 1939. Price $3.00.)

If a copy of this book should fall into the hands of a scientific-minded layman, it could very well convert him into an amateur astronomer. It would have an appeal to a bright high school boy, not only by telling him of the results of research in astronomy and allied sciences, but also by giving to him a challenge, the challenge to find out more about this wonderful universe around us and apply the knowledge to the benefit of man.

The book is authoritative and factual, but not dry. It treats, as the title suggests, of the universe, the various heavenly bodies, our earth, as well as the ultimate entities of matter, time, radiation, and energy in a non-mathematical manner. It escapes from being a compendium of information by including challenging questions about the "why and wherefore" problems which are still on the borderline of speculation today.

Typographically speaking, the book is an attractive piece of work. Several plates, drawings, sky maps, and a glossary enhance its value.

High school libraries should have this book upon their shelves. General science teachers could use this book with value, both as a summarizing source book, and as a reference for their students. Finally, some of those readers of POPULAR ASTRONOMY who from time to time ask for "popular" literature on their hobby would find this book of value and interest. M.M.H.

The Psychology of Physics, by Blamey Stevens. (Sherratt & Hughes, Manchester, 1939. Price 7/6.)

This book is described as a course of rational psychology, prepared for the use of elementary students. However, the author does not expect the student to follow easily the line of reasoning, and suggests that re-reading will be necessary. In each chapter the author asks a succession of questions and answers them. Concerning his purpose he writes: "This prejudice (against psychology) is perhaps justified in the case of the psychology of traits and emotions, but the kind I have introduced is physical, it deals with new conceptions of space, time, and inertia, and shows that the relations of these entities to one another are purely psychological ones, which are not based on any external or objective reality, as the present-day physicist conceives them to be, in spite of what he may say or think he believes. Moreover, since these relations are also the laws of physics, in this sense physics is

purely psychological or intuitional."

The development discards axioms and constructs the laws of physics from three fundamental postulates. Space, time, and inertia are treated as "three subjective aspects for the theoretical classification of objective nature"; and at the beginning he writes: "I first ask you to eliminate any ideas you may have of 'action at a distance,' because you cannot even make a start on any kind of physical reasoning if you have such ideas. All action of one body on another at a distance from it, must be through some kind of medium, and such a medium, whatever it is, I call ether." Space and time are stated to be infinite. The generally accepted features of modern physics are regarded as an irrational interpretation, and the photon hypothesis and special relativity are shown to be fallacious. Experiments supposed to be proof of special relativity, such as that by Ives and Stilwell, are viewed as proof of the opposite. It is shown that in the Kaufman and Bucherer experiments mass may be regarded as constant, and that the field due to the charge should change in such a manner as to account for the observed behavior. Assigned values of electron energies in the current literature are called fabulous inflations the use of which is detrimental to clear conception in nuclear mechanics.

The appendix contains many references to important literature in the history of physics, and is followed by a table of physical constants and their logarithms. It ends with a note on the philosophical aspect of the psychology.

Carleton College. R.B. Q.

The Pinpoint Planetarium, by Armand Spitz. (Henry Holt & Company, 1940. $2.00.)

Engaging in the simplicity of its style, this book aims to give the would-be amateur astronomer, young or old, an appealing approach to the study of the constellations and planets. In place of the rotating sky charts one finds ingenious cut-out designs, which with the help of scissors and paste become sky domes. Pinpoints placed in the domes, by allowing light to pass through, enable the observer to locate easily the desired star or constellation.

Especially enjoyable are the author's comments on star lore and the mythology connected with asterisms. "The Sun's Family" is treated somewhat briefly but important essentials are given. The list of sky events through 1945 should be helpful to the amateur observer.

This volume will prove to be fascinating to those who wish to increase their non-technical knowledge of the heavens.

GERALD B. HOOVER.

Carleton College.

The Birth and Death of the Sun, by George Gamow. (The Viking Press, New York, 1940. Price $3.00.)

This book could be named "Astrophysics Made Enjoyable," but it would not reach the readers for whom it is intended. It is a popular exposition of the studies in atomic structure and atomic energy from the time of Democritus down to the present age of cyclotrons and atom-smashers. Included is an introduction to cosmology, with presentations of the various theories of the evolution of the universe, the emphasis being on contemporary ideas based on hypotheses and research. In both of the above problems, Professor Gamow has himself made a considerable contribution. The various theories and facts are given in logical sequence, care being taken to show that scientists are indebted both to their predecessors and contemporaries.

The book is another of those with a definite mission, such as, for example, Sir Wm. Bragg's "Concerning the Nature of Things," published some years ago. The mission is to reach the serious minded layman, or amateur scientist, and give to him scholarly, yet not too technical résumés of scientific thought. All mathematics, both empirical and theoretical formulae, has been omitted, and the practical results given in simple graphs and word expressions. An attempt is made to avoid conclusions on questions still controversial. The book is factual, yet the style is easy, and not entirely devoid of humor. The author regrets the necessity for the excursion into the realm of pure physics, "but," he says, ". . . except for poets, no one should speak about the stars without knowing the properties of matter of which they are constructed." Several plates of celestial objects and other pertinent items lend interest. The reviewer read the book at one sitting; this may be taken as a recommendation. M.M.H.

Apparent Places of Fundamental Stars, 1941. (His Majesty's Stationery Office, London, W. C. 2. Price £1 10s + postage.)

This volume contains 538 pages of rather condensed information concerning the positions of stars in 1941. It is a result of the unifying influence of the International Astronomical Union, the computations having been furnished by France, Germany, Spain, and the United States. Great Britain collated the material and the British Government bore the expense of printing. It is planned to issue a similar volume annually, so that the work of reduction of observations and the determination of time may be facilitated.

The concluding paragraph in the preface, written in January, 1940, sounds quite remote, in consideration of events between that time and the date of this issue. "It is gratifying that the coöperation recommended by the International Astronomical Union has proved possible, and that Great Britain should publish the combined work of five countries under the auspices of that Union. The annual volume of apparent places of stars will meet a need that has long been felt by observatories engaged in fundamental observations or in the determination of time."

Total Eclipse of the Sun, October 1, 1940.—This is the title of a 57-page pamphlet issued by the Nautical Almanac Office as a supplement to the *American Ephemeris* for 1940. It contains detailed information concerning the path, the time, the probable weather conditions, the accessibility and suitability of places for eclipse expeditions, and other facts concerning the eclipse. Large scale maps of South America and Africa are included. The total eclipse begins just at the northwest edge of South America at sunrise and ends a short distance east of the southern tip of Africa at sunset. The duration of the eclipse will be in the neighborhood of four minutes, long enough to entice eclipse hunters to its path. This pamphlet will be of great value to those who may be planning such a journey.

Astronomy.—A pamphlet of 52 pages bearing the title "Astronomy, A Guide," has been issued by The University of Chicago Press, for use with the four instructional sound films, "The Earth in Motion," "The Solar Family," "The Moon," and "Exploring the Universe." It is indicative of the new type of material now available for the schools. The pamphlet may be purchased for fifteen cents.